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Pre-Columbian Agriculture in the Southwest, as Conditioned by Periods of Alluviation

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INTRODUCTION

One of the paradoxes of cultural development in both the New and Old Worlds is the relatively high position of the early human societies of arid lands. These regions which, before our eyes, are, or are rapidly becoming relative "ghost towns" were once the bonanzas of human enterprise. The arid highlands of Peru and Mexico, united with the seasonally dry tropics to furnish the foci of human development in the New World. From these areas came the cultivated plants and the imperfectly domesticated llama and turkey. Peripheral to them lay the more or less independent development of semi-civilized life in Southwestern United States. Utilizing maize, squash, and beans—plants originated far to the South—as the basis of agriculture, there was here developed the most advanced pre-Columbian culture within the boundaries of the United States.

The Puebloan[1] or Anazazi culture founded on agriculture was rivaled only by the Hohokam or Gila Basin culture to the South.

As outlined in Figure 1 the homeland of the Puebloans is bounded on the north by highlands and mountains. The open valleys of these highlands, prized by white men and farmed for hay, oats, and peas, were unat-

[1] "Puebloan," the adjective, is here used in preference to the noun "Pueblo." It includes the development stages of the archaeological sequence and thus includes both "Basketmaker" and "Pueblo."

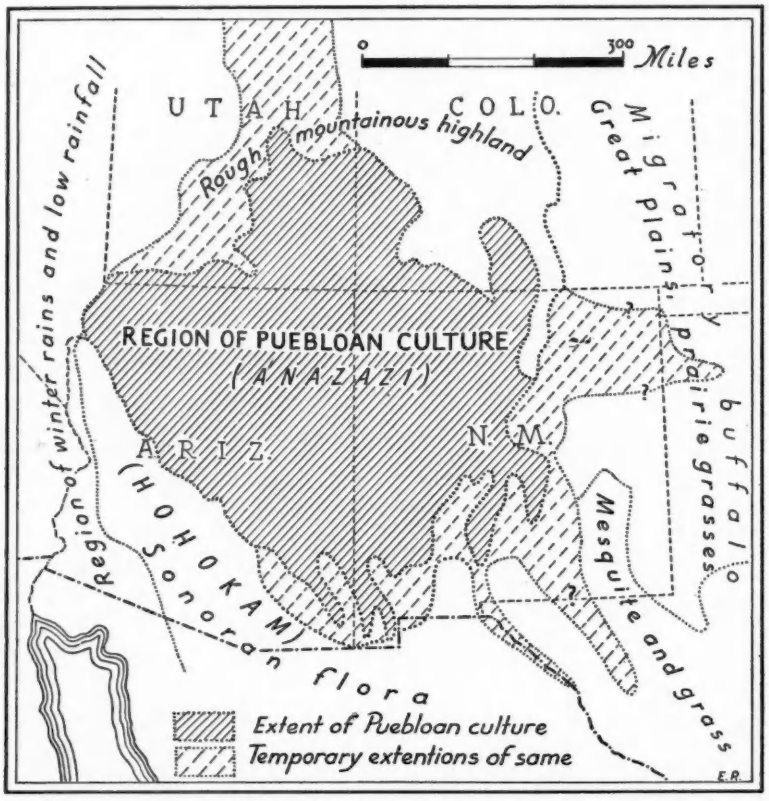

FIG. 1.—The region of Puebloan culture with its natural boundaries. Temporary extensions of the Puebloan culture are indicated.

tractive to primitive agriculturists whose principal crop was corn. In general, areas above 7500 feet in elevation have too short a growing season, and corn does not always mature. Such areas were seldom occupied by the Puebloans. Settlements in such areas appear to have lasted only a short period of years.

To the East the Puebloans were limited by the Great Plains. At various times they thrust settlements into this area, but none persisted for any length of time. This area is suitable for corn growing and actually has a heavier summer rainfall than the Puebloan area. It was, however, the range of the buffalo, whose migration from summer range in the north to winter range in the south was the outstanding characteristic of the area from the stand-

point of primitive man. The tribes that followed the buffalo could easily raid the fields of farmers and were thereby a deterrent to permanent settlement in an area otherwise favorable. When, after the Spanish Conquest, the Plains Indians acquired horses, their raids into the Pueblo Country became much more formidable and led to the abandonment of Pecos in 1838.[2]

To the west the Puebloan area is bounded by the hot deserts of southern Nevada and southeastern California. Not only is the rainfall meagre but a larger proportion falls in the winter. The summer rain necessary for corn is lacking here and in coastal California and was the principal obstacle to the spread of higher civilization westward. The desert tribes lived by hunting and food gathering except for those who fished the Colorado and Gila rivers and planted corn on the wet ground left by the spring floods.

The southern boundary of the Puebloan area corresponds closely to the northern boundary of the Sonoran flora and of the corresponding "mesquite and grass" flora of the Texas area.

The Hohokam lived within the zone of the Sonoran flora which produced a large variety of wild foods to be had for the gathering. Thus an individual or family was free to wander off and eke out a precarious but independent existence without complete reliance on farming or the aid of the farmer. The result was a social organization more diffuse than that of the Puebloan.

Many large groups occupied scattered rancherías of brush huts and lived by transhumance. In summer they planted flood-water fields in localities having only rainwater pools, and in winter they retreated to areas with permanent water. Other large groups built great canals and lived by irrigation agriculture in the lowlands of the perennial rivers. All, however, were dependent in large part on the gathering of the relatively abundant food furnished by the Sonoran flora.

To the north, in the cooler zone of the Transition flora, the communal societies of the Puebloan peoples developed. Here the severity of the winter climate and the paucity of wild food inhibited the straying of individuals or families. All were bound to the available tracts of farmable land and to the community.[3] Furthermore, the almost complete absence of June rain and the short growing season increased the hazards of agriculture although the total annual rainfall equals or exceeds that of the Sonoran

[2] Kidder, A. V.: An Introduction to the Study of Southwestern Archaeology, etc., *Phillips Academy, Andover, Southwest Expedition, No. 1,* pp. 14–15 (New Haven) 1924.

[3] Lists of wild plants used by the Puebloans are long, but only the fall harvest of piñon nuts was of large importance in the economy.

Zone. The community with a holdover of corn and beans from the last harvest, was a refuge not lightly deserted. Also each community was separated from the other by lands not only almost barren of wild food but largely depopulated of game by reason of the seasonal hunting of each community. Raids by hunting tribes or by renegades were possible but ineffective against the fortified towns. Long sieges of these towns by people with merely the usual tribal organization and consequent lack of a commissary were infeasible. Thus each community became a unit, safe from outside interference and also from desertion by the seditious. The unity of the community, through time, expressed itself in that almost perfect integration of government, religion, and economic life which we know as the Puebloan culture. In these tightly-knit villages, disruption by individuals became almost impossible, but major schisms doubtless occurred. The founding of new villages may have been preceded by political controversy —party division so severe as to require separation. An example of such a schism is the recent partition of Oraibi to form the new pueblo of Hotevilla in 1906. It is not, however, a perfect homologue as it occurred under the *pax americana*. In pre-Columbian days the fear of other communities and of the hunting tribes must have damped the ardor of seditious parties and restrained schismatics.

The gradual development of the Puebloan culture from humble beginnings to its climax is coming to light. The patient and indefatigable work of a group of archaeologists of outstanding ability has painted for us a picture of this cultural rise.[4] Beginning in a postulated non-agricultural stage[5] known as Basketmaker I, the Puebloans gradually developed into an

[4] For summaries of knowledge of the Puebloans see:

Kidder, A. V.: *op. cit.*

Roberts, Frank H.: *Bur. Amer. Ethnol. Bull. 96,* 1930.

———: Southwestern Archeology, *Amer. Anthrop. n.s.,* vol. 37, pp. 1–35 (Lancaster, Pa.) 1935.

[5] The standard chronology of Puebloan archaeology, dated by the use of the tree ring method of Douglass, is as follows:

Pueblo	V	1600
"	IV	1300 to 1600
"	III	1100 to 1300
"	II	900 to 1100
"	I	700 to 900
Basketmaker	III	500 to 700
"	II	? to 500
"	I	postulated

Various authorities use slightly different dates, and some question the reality of the boundaries between some of the categories.

agricultural people, and in the stage known as Basketmaker II, lived in groups and practiced many simple arts.

The advance in cultural status was influenced and aided by the development of new varieties of maize better adapted for use as food and hardier under the severe growing conditions of the region.[6] In the Basketmaker III stage, pottery was introduced, shelters were built in caves and in the open. Gradually improvements in the arts occurred, and larger and larger villages were built.

In the San Juan basin, the acme was reached by the end of Pueblo III time, and prosperous and busy communities were then deserted never to be reoccupied (Fig. 2). As much of the earlier archaeological work was done

FIG. 2.—Map of the South West showing localities mentioned in the text.

[6] Mangelsdorf, P. C., and R. G. Reeves: The Origin of Indian Corn and Its Relatives, *Tex. Agric. Exper. Statn. Bull. 574*, pp. 256–257, 1939.

in this region, it has been generally held that the desertion of this area marked a great decline in Pueblo culture. More recent work, particularly the excavation of Awatovi[7] in the Hopi country has modified this view. Pueblo IV was a period of growth in culture and in population in the Hopi land. The new people were immigrants displaced from the Kayenta region. Similarly, the Rio Grande and Little Colorado areas, although the evidence is not yet entirely clear, appear to have benefited by the incoming of peoples from the San Juan.

The prime fact seems to be that the cultural changes at the close of Pueblo III time or about 1300 A.D. were the result of migration. Certain areas were deserted, and others received additional population. The human events were in accord with climatic and geologic events, for at this time a great drought occurred and deep arroyos were cut in many streams.

In this paper, the agricultural practices of the Puebloans will be described. The effect on these practices of alternate periods of erosion and alluviation will be discussed. The available information on the correlation of local sequences of erosion and alluviation will be summarized. This material will be analyzed to set forth the relation of these geological events to possible changes in climate, and to geographic changes which affected the distribution of the pre-Columbian agricultural population.

FLOOD-WATER FARMING

In the Southwest, rainfall is low except at high altitudes where the growing season is too short for corn. Thus agriculture is possible only by the use of specialized methods such as flood-water farming. This system of agriculture has been much described,[8] but its simplicity conceals its importance in the economy of arid lands. The essential feature is the selection for planting of a place overflowed by flood water. The overflow must be sufficient to saturate the ground and thus irrigate the crop and yet not so violent as to wash out the plants. Thus part of the rainfall of a large area is utilized on a small one. The user of this method must have a grasp of

[7] Brew, J. O.: Preliminary Report of Peabody Museum Awatovi Expedition, *Amer. Antiquity*, vol. 5, no. 2, Oct. 1939, pp. 103–114.

[8] Gregory, H. E.: The Navajo Country, etc., *U. S. Geol. Survey, Water-Supply Paper 380*, pp. 102–105, 1916.

Bryan, K.: Flood-Water Farming, *Geog. Rev.*, vol. 19, pp. 444–456, 1929.

Hoover, J. W.: Tusayan—The Hopi Indian Country of Arizona, *Geog. Rev.*, vol. 20, pp. 425–444, 1930.

Forde, Daryll: Hopi Agriculture and Land Ownership, *Royal Anthrop. Inst. Jour.*, vol. 61, p. 357, 1931.

Hack, John T.: The Physical Basis of Hopi Agriculture (Report of the Peabody Museum Awatovi Expedition), *Harvard Univ. Peabody Museum Papers.* [In Press.]

the principles of run-off and stream flow, local knowledge, and skill of a high order.

The physical conditions must also be propitious. Broad valley floors over which the flood run-off after a rain spreads widely are favorable areas. Narrow valleys or large rivers with perennial flow are relatively unfavorable. In the plateau area of northwestern New Mexico, northern Arizona, and southern Utah, the favorable conditions were fulfilled, and this appears to be the original homeland of the Pueblo. Here the silty floods of ephemeral streams spread in the broad alluvium-filled valleys, furnishing ideal sites for flood-water farms.

It is to be presumed that another form of flood irrigation prevailed along the main rivers. As in early Egypt, planting on the moist ground after the spring floods was doubtless practiced. On the Colorado River, the Yuma and nearby peoples may have practiced this method of agriculture, but the less regular floods of the Rio Grande must have made it a relatively hazardous form of agriculture there.

Irrigation with living water is an agricultural method that was also used in the region. By the use of dams and ditches the relatively clear water of perennial streams was led to the fields. This method was well-known to the inhabitants of the Gila region where Haury[9] has proved that ditches were in use from 800 to 1300 A.D. In the Pueblo area such complete evidence has not been gathered. However, one cannot doubt that at Taos, Picurís, Nambé, Jemez and other villages, living water was diverted to the land before the first Spanish exploration by Coronado in 1540 A.D. But in the same general area the villages of the Tano people, Galisteo, San Cristóbal, and others, were located in valleys without perennial streams where flood-water farming must have been the agricultural method. The greatest and some of the earliest centers of the Puebloan cultures—Chaco, Kayenta, and others—were located far from perennial streams. Even today the Hopi, Zuñi,[10] and Acoma[9] farm largely by flood-water methods. The question may be raised whether in the Pueblo area the diversion and use of living water is not a recently acquired trait. Pending the location and excavation of ditches and other irrigation structures definitely tied by archaeological methods to the earlier settlements of the Puebloans, this question cannot be conclusively decided. In a general way, however, it can be stated that by far the greater number of sites and villages of Basketmaker

[9] Haury, E.: The Snaketown Canal: Symposium on Prehistoric Agriculture, *Univ. N. Mex. Bull. no. 296*, Anthrop. Ser. vol. I, no. 5, pp. 48–50, 1936.

Judd, Neil M.: Arizona's Prehistoric Canals, from the Air, *Smithson. Inst. Explor. and Field-Work in 1930*, pp. 157–166, 1931.

[10] Except on lands settled within the past 40 years.

and early Pueblo time are located in or adjacent to valleys which contained no living water. The inhabitants must have practiced "dry farming" or flood-water farming.

Granted that flood-water farming was, therefore, of prime importance in the economy of the Pueblos, any changes affecting this system of agriculture must have had large cultural repercussions. Such a change has taken place within the past 55 years, for during that time many of the streams of the Southwest have deepened their channels. Whereas they once flowed in shallow channels and overflowed at each flood onto broad flood plains, they now run in gullies or arroyos 10 to 100 feet deep. This change began about the year 1885 and continues to the present. Many historical data have been gathered as to the original character of the streams and the date of the change.[11]

The process of arroyo cutting is more advanced on some streams than on others. The flood plains of some valleys have been almost wholly destroyed, and the areas once available for flood-water farming no longer exist. In other valleys only the main stream has cut a channel, and the minor streams still flood widely and afford sites for fields. In a few localities a general cover of wind-blown sand interferes with surface drainage and inhibits the growth of a complete system of arroyos. In these favored places, such as the valley at Old Acoma, the head-water area of Chaco River above Pueblo Pintado, and the Hopi country, flood-water farming still flourishes.

PERIODS OF ALLUVIATION AND EROSION

The cutting of arroyos through the valleys of the Southwest has exposed the alluvium to depths ranging from 10 to 100 feet. In places the arroyos have cut to the bedrock floor and expose the full thickness of the alluvial fill. Elsewhere the alluvium is deeper than the arroyos. Long-continued study has shown that the alluvium of any one valley is of several ages. In favorable places it can be divided into two or three bodies of alluvium, separated from each other by steep erosional boundaries that resemble the walls of the modern arroyo. It is plain that each stream has alternately filled its valley with alluvium and then cut a gully similar to the modern arroyo (Fig. 3).

[11] Bryan, Kirk: Date of Channel Trenching (Arroyo Cutting) in the Arid Southwest, *Science, n.s.*, vol. 57, pp. 339–344, 1925. (Bibliography of earlier papers.)

———: Channel Erosion of the Rio Salado, Socorro Co., N. M., *U. S. Geol. Survey, Bull. 790-A*, pp. 17–19, 1927.

———: Historical Evidences of Changes in the Channel of Rio Puerco, a Tributary of the Rio Grande in New Mexico, *Jour. Geol.*, vol. 36, pp. 265–282, 1928.

———: Change in Plant Associations by Change in Ground Water Level, *Ecology*, vol. 9, pp. 474–478. 1928.

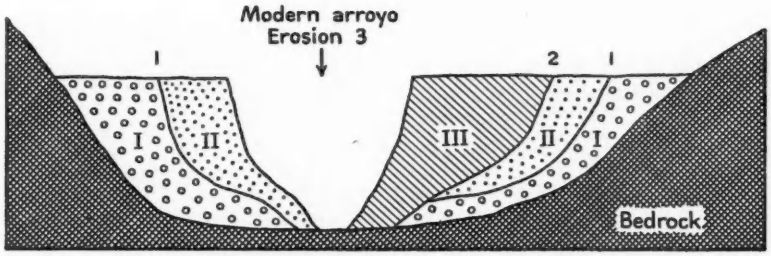

FIG. 3.—Idealized cross-section of southwestern valley showing a characteristic arrangement of three alluvial fills and position of the erosional surfaces.

In some valleys the earlier alluvial fills rise to elevations above the later and thus form low terraces. In other valleys each body of alluvium rises to about the same level. In such places the complexities in the history of the alluvium would be unsuspected were it not for the exposures in the banks of the latest gully or arroyo—formed within the past few years.

There have been at least three periods of alluviation and, including the present arroyo, three periods of erosion. The pertinent studies[12] are summarized in Table I.

THE PROBLEM OF CORRELATION

The problems of correlation are twofold. There is first the problem of the detection and separation of the several alluvial fills in a single valley. Adequate and skillful field study is required. There is the further problem of correlation of the deposits from stream valley to stream valley and from area to area. These correlations rest largely on cross-dating by fortunate archaeological finds or on general argument. These methods yield results that are as yet tentative and subject to revision as further facts accumulate.

The field discrimination of the several bodies of alluvium rests on minute differences in materials similar in general character. In any one valley all are laid down by the same stream. In general the oldest body of alluvium is slightly cemented. It may also have zones of weathering or calichifica-

[12] Bryan, Kirk: Recent Deposits of Chaco Canyon, N. M., in Relation to the Life of the Pre-historic Peoples of Pueblo Bonito (Abstract), *Wash. Acad. Sci. Jour.*, vol. 16, pp. 75–76, 1926.

———: Stone Culture Near Cerro Pedernal and Their Geological Antiquity, *Tex. Arch. and Pal. Soc. Bull.*, vol. 11, p. 9–42, 1939.

Albritton, Claude C. Jr., and Kirk Bryan: Quaternary Stratigraphy in the Davis Mountains, Trans-Pecos, Tex., *Geol. Soc. America Bull.* vol. 50, pp. 1423–1474, 1939.

Hack, J. T.: The Late Quaternary History of Several Valleys of Northern Arizona: A Preliminary Announcement, *Mus. North. Ariz. Notes*, vol. 11, pp. 63–73, 1939.

———: The Physical Basis of Hopi Agriculture, *cit.*

TABLE I

EROSION AND SEDIMENTATION IN THE FLOOD

Investigator	Albritton and Bryan 1938	J. T. Hack 1936–39	Bryan 1937–38
Streams & localities	Trans-Pecos region near Alpine, Tex.	Hopi Country, Ariz.	Rito de los Encinos (lower Chama River, N. M.)
Present epicycle of erosion (3)	Arroyo cut since 1880?	Arroyo cut since 1900	Arroyo (date ?)
Deposition (III)	Kokernot formation. Deposition began 1100 to 1400 A. D.	Naha formation began to form after (No. 3 fill) 1300 to 1400 A. D.	Late Alluvium Pueblo?
Erosion (2)	Arroyo similar to present: before 900 to 1300 A. D.	Arroyo similar to present after 1100 A. D.	
Deposition (II) (formations listed may belong to two or more periods)	Calamity formation	Tsegi formation (No. 2 fill)	Intermediate alluvium Los Encinos culture
Erosion (1)	Arroyo very large, wind action	Arroyo very large, much wind action	Arroyo
Deposition (I)	Neville formation *Elephas, Equus*	Jeddito formation (No. 1 fill) proboscidean	Early alluvium, proboscidean

* Unpublished data.

tion differing in intensity or in kind from that found in later bodies. Moreover, beds laid down in shallow ponds, greater humus content, or other indications of a moister climate may be present. The bones of extinct animals are found here and there. Thus there are three criteria (1) greater cementation, (2) indications of deposition in a somewhat moister climate, (3) presence of the bones of extinct animals, usually proboscidea. However, the time of extinction of the several now extinct animals is as yet unknown. The several species and genera lived over a long period. Consequently the oldest alluvium in the valleys of Arizona, New Mexico, and Texas shown as of equivalent age in Table I may in fact be of different ages.

The period of erosion which followed the deposition of these older allu-

TABLE I

PLAINS OF VALLEYS IN THE SOUTHWEST

Bryan* 1924–25	Bryan* 1927	Bryan* 1929 & 1937	Bryan* 1929
Chaco River N. M.	Zuni River N. M.	Rio Puerco (of the east) N. M.	Rio Galisteo, N. M.
Arroyo since 1860	Arroyo since 1860	Arroyo since 1880	Arroyo since 1880
Buried channel after 1167 A. D.	Buried channel (no date)	Buried channel (no date)	Buried channel before 1400 A. D.
Arroyo similar to present	Arroyo similar to present	Arroyo similar to present	Arroyo similar to present
Main fill (Pueblo date)	Main fill (no date)	Main fill (no date)	Main fill (no date)
Arroyo very large	Arroyo very large	?	?
Terrace? (no date)	Terrace (no date)	?	?

vial beds, in every area, was a long one. Great gullies wider than the modern arroyo were formed. In many valleys the older alluvial beds were so completely removed that remnants cannot now be found. Furthermore, in the Big Bend region of Texas and in the Hopi Country this episode of erosion is associated with wind-blown sand and evidence of aridity. There is little doubt that the older beds, here attributed to the first period of deposition, are separated from the younger by a considerable interval of time and by a marked change in climate. Unfortunately evidence of the presence of man is missing or scarce. If as suggested the Durst silt[13] of the Abilene

[13] Kelley, J. Charles, and T. N. Campbell: The Association of Archaeological Materials with Geological Deposits in the Big Bend Region of Texas, *Sul Ross State Teachers College Bull.*, vol, 21, pp. 133–153, 1940.

area of Texas and the lower horizons[14] of Whitewater Creek in Sulphur Springs Valley of Arizona can be correlated on archaeological grounds and these in turn correlated with the formations here discussed a fairly firm basis is at hand. It should, however, be recognized that new finds of cultural remains may reveal a more complicated history than we would be justified in postulating on the existing evidence.[15]

The beds attributed to the second period of alluviation in Table I are almost certainly of two or more ages. The Tsegi formation of the Hopi country is in places divided by an unconformity. The age of the lower part is unknown; the upper is definitely older than Pueblo III or 1100 A.D. Other beds such as the "main fill" at Chaco Canyon contain pottery of Basketmaker III type. This deposit must therefore have been laid down after the time in which the pottery was made or after 500 to 700 A.D. and presumably continued to be deposited up to 1250 A.D. In the Big Bend region cultural remains were found on the erosion surface on which the Calamity formation was laid down. Various finds prove that the region was occupied during deposition of the Calamity. By a comparison of the finds from the upper part of the Calamity with cultural evidence of known age in the Pueblo Country, a date lying between 300 A.D. and 900 A.D. can be postulated. This date does not apply to the lower horizons. In other areas attempts at dating the archaeological remains are unsatisfactory. Thus the second period of alluviation shown in Table I is as yet unsatisfactorily dated and it is possible that two episodes of alluviation separated by an interval of erosion took place and have not yet been differentiated.

The second alluvial fill was dissected and a gully formed comparable in depth and width to the existing arroyo. In this gully was deposited a new body of alluvium which in many valleys reached the level of the older alluvial fills. The streams thereafter flooded widely and put a veneer of later materials over the older material.

This second gully and the youngest alluvial fill which overlies it can be dated with some measure of precision. In Chaco Canyon, the gully formed after the completion of Pueblo Bonito, a ruin whose latest known beam was cut in 1167 A.D., and which must have been deserted some time later. The buried channel contains an abundance of potsherds of the latest types made in the Pueblo. They are the typical Pueblo III of the locality. Although the latest date of a cutting of a beam is 1167 A.D. the best archaeological opinion is that the pueblo was occupied for 100 years thereafter. On this

[14] Antevs, E.: Age of the Cochise Culture Stages, *Medallion Papers 29*, pp. 38–39 (Globe, Ariz.), 1941.

[15] Kelley and Campbell (*op. cit.*, pp. 158–162) have brought all the archaeological evidence together and hold that all the earlier beds may easily be of the same age.

reasoning the beginning of the period of deposition can hardly be earlier than 1250 A.D.

In the valley of Galisteo Creek, the buried channel underlies Pueblo Galisteo, a large ruin inhabited in early Spanish time. The earliest type of pottery from this ruin is Glaze I, attributed to 1400 A.D. The gully must have formed and have been filled before this town was built or before 1400 A.D.

In the Hopi country, the post-Tsegi gully in Jeddito Wash destroyed a portion of a Pueblo II ruin, and thus is later than some date between 900 to 1100 A.D.[16] It is Hack's opinion that the gully was cut late in Pueblo III time or after 1250 A.D. The Naha formation which fills the gully contains abundant potsherds of which the latest types are Pueblo IV and thus the gully filled after 1300 to 1400 A.D. The gully may possibly be somewhat older than that of Chaco Canyon, but the beginning of the process of filling is probably no later.

In Trans-Pecos Texas, a refuse mound extends down the sloping bank of the post-Calamity gully. The artifacts of this refuse belong to a culture dated by a roundabout argument between 900 and 1300 A.D. The filling of the gully, the Kokernot formation, contains artifacts dated as early as 1200 A.D. It may be, however, that this date should be 1400 A.D., and the pre-Kokernot erosional interval should be correspondingly later.[17]

In these widely separated localities the third fill and the gully previous to it are contemporaneous. On the other streams shown in Table I, and on streams not named but partly investigated, the most recent deposits or buried channels are similar in size and character of fill, and are thus presumably of the same age, but datable relics of man have not been found.

On the foregoing data the next to the last period of gullying began in many places after 1100 and in the Chaco, where the evidence is best, after 1200 A.D. In every locality where data are available, the filling of the gullies began before or shortly after 1400 A.D. and was completed either by that time or not long after. Such a close synchrony in erosion and subsequent alluviation over a wide area from Texas to Arizona is a remarkable fact.

Various authors have assumed or implied that erosion and alluvial filling in these valleys has occurred at irregular intervals in the past. They believe that the arroyos which began to form after 1885, the third erosion period of this paper, are thereby the only synchronous episodes recorded. The evidence briefly outlined above indicates that this contention is incorrect. The second period of erosion and the third fill fall within too narrow a range of dates.

[16] Hack, John T.: The Physical Basis of Hopi Agriculture, *cit.*

[17] Kelley and Campbell: *op. cit.*, p. 161.

SYNCHRONEITY AND CLIMATIC CHANGE

The cause of the recent episode of erosion, the deepening and widening of channels, has excited much debate. The process of arroyo-cutting or "epicycle of erosion" is at least the third and perhaps the fourth in a series of such episodes. Each, except this last, has been followed by a period of alluviation when the destroyed flood plains have healed and streams have once again flowed in shallow channels in broad flood plains.

As Huntington[18] pointed out, a diastrophic cause for the alternate periods of erosion and sedimentation seems to be impossible. On such a theory one could suppose that the cutting of arroyos might have been induced by tilting of the valleys so that the headwater portions would be raised with respect to the lower portions. Thus the streams would hold the same gradient, but would cut into their flood plains. However, the supposition that so many streams flowing in diverse directions over a broad extent of country could have been tilted at the same time requires a simultaneous set of earth movements so complicated as to be beyond conception. This argument attains greater force when it is realized that the tilting must be supposed to occur at least thrice and that it must be as many times reversed.

It seems obvious that the cause must lie in some alteration of the regime of streams by which their erosive force is increased and thereafter decreased. One school [19] holds that the recent arroyo-cutting is due to overgrazing induced by the commercial exploitation of cattle and sheep. The vegetative cover has been reduced and thereby the floods of ephemeral streams have been increased. These increased floods have deepened and widened the channels of streams, lowered the water table in valley flood plains and thus produced the present state of accelerated erosion.

It is true enough that the present epicycle of erosion began after 1885 A.D. Since that date stream channels have deepened and widened. Undissected valleys still exist but are menaced by the headward growth of arroyos. The beginning of those events in 1885 was also the beginning of the commercial cattle business when herds spread from Texas westward. The same period saw the expansion of the sheep business. But Gregory[20] noted that the erosion of arroyos occurred in the Marsh Pass region before the introduction of stock. Furthermore, no such general accelerated erosion has occurred in Wyoming or Montana, although one cannot doubt that overgrazing has been as great in those states as in more southerly localities.

[18] Huntington, E.: *The Climatic Factor,* Carnegie Inst. Pubn. no. 192, 341 pp., 1914.

[19] Many authors, but best stated by Bailey, Reed: Epicycles of Erosion in the Valleys of the Colorado Plateau Province, *Jour. Geol.,* vol. 43, pp. 337–355, 1935.

[20] Gregory, H. E.: Geology of the Navajo Country, *U. S. Geol. Survey, Prof. Paper 93,* pp. 130–132, 1917.

Some general causes other than overgrazing must be sought for the pre-Columbian episodes of dissection. Whatever the cause of the recent arroyos, overgrazing by domestic animals can have had no influence on the formation of the early arroyos. The Pueblos and their less-settled neighbors had no grazing animals previous to the Spanish conquest. In fact there was a considerable lag in time between the expedition of Coronado in 1540 and the introduction of any considerable number of horses, cattle, and sheep. The use of stock was learned by the Pueblos after the colonization of New Mexico began in 1602. As late as 1700, Kino was having difficulty introducing cattle among the Indians of Southern Arizona, although the Apaches were by that time accomplished horse thieves.

Overgrazing by herds of buffalo or other herbivorous animals has been proposed as a cause of arroyo cutting,[21] but such a reason is fantastic, as animals free to wander and not confined by man leave areas of poor grazing for better areas, or weakened by lack of food in droughty years, succumb to disease or to their predatory enemies. It is well-known that there is a cyclic fluctuation in the number of rabbits and other small mammals. Whether such fluctuations in number of the larger herbivorous mammals occurred in pre-Columbian time is unknown but entirely probable. Certainly at present antelope and wild sheep are known to multiply and then suddenly decrease in number by reason of disease. It seems unlikely that a large population could exist and suffer from scant grazing, without also suffering from a devastating disease.

Reagan has also contended that the period of alluviation which preceded the present epicycle of erosion was due to the work of the Pueblo people. He holds that they built so many small dams to spread flood waters, so many catchment basins to store water, as to restrict floods and cause the streams to alluviate. Since Reagan's paper was written, the latest period of alluviation has been defined. Its extent—from 1400 to 1885 A.D.—has become known. Also much labor has been expended on archaeological study. The San Juan District to which his hypothesis applies was largely deserted by the Pueblos during this time interval, so that in this area their activity could have had no effect. Furthermore, no great abundance of dams, reservoirs or other works has been discovered in the localities in the Pueblo area which were inhabited during this interval. Here and there flood water spreaders were built. Here and there *trincheras* may have

[21] Reagan, A. B.: Recent Changes in the Plateau Region, *Science, n.s.* vol. 60, pp. 283–285, 1924.

———: Stream aggradation Through Irrigation, *Pan-Amer. Geologist,* vol. 42, pp. 335–344, 1924.

———: Archaeological Notes on the Pine River Valley, Colo., and the Kayenta-Tuba Region, Ariz., *Kansas Acad. Sci. Trans.,* vol. 30, pp. 244–331, 394–420, 1921.

been built.[22] The alluviation during this period is out of all proportion, however, to these feeble human efforts. Moreover, such an hypothesis could apply only to the alluvial fills produced during occupation by Pueblos or other peoples of a relatively high stage of culture. The hypothesis affords no explanation for the periods of alluviation recorded by the Neville or Jeddito formations and alluvium of similar pre-Puebloan antiquity.

There remains the hypothesis of climatic change which was proposed by Huntington and supported by Gregory.[23] The subdivision of the alluvium set forth in Table I requires not one climatic change, but at least three fluctuations from wet to dry. It is necessary to define the limitations of these supposed fluctuations. The postulated periods of drought are only relatively dry; the periods of wetness are only relatively wet. There is no indication that the Chaco River, the Rio Galisteo, the Zuñi, or any of the streams of the Hopi country carried living water. They were at each period ephemeral streams like their counterparts of the present. The alluvium representing the periods of wetness was deposited by streams similar to those of the present day. The Jeddito formation contains a few limey beds that seem to represent shallow ponds and on this ground and the presence of a proboscidian, a wetter flood plain than the present can be assumed. Also in the Trans-Pecos Texas, the Neville shows soil horizons made under conditions apparently moister than the present—a conclusion justified also by the presence of *Elephas*. Those familiar with these areas at present will realize that a gross-feeder like an elephant would have difficulty in finding enough to eat.

A climatic cause for alternate alluviation and dissection by streams assumes that run-off is largely regulated by vegetation. In periods of relatively high rainfall the slopes have a correspondingly dense vegetative cover which retards run-off. Thus floods are more moderate. Furthermore, the flood plains of streams have a denser vegetation which also spreads the floods and prevents the formation of channels. In periods of relatively low rainfall, there is a sparser vegetative cover. The individual rains are, however,

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[22] The reader will note that the word "trinchera" is applied to rough dry-laid rock walls built across valleys to retain soil and spread flood-water and also to walls retaining soil terraces. In Peru and elsewhere these soil terraces were used for agriculture. The "trincheras" built on rocky hills in northern Mexico and Arizona are thought to have been fortifications.

Sauer, C., and D. Brand: Prehistoric Settlements of Sonora, etc., *Univ. Calif. Publns. Geog.*, vol. 5, 1931.

Hoover, J. W.: Cerros de Trincheras of the Arizona Papaguería, *Geog. Rev.*, vol. 31, pp. 228–239, 1941.

[23] Huntington: *op. cit.*, pp. 33–34.

Gregory: *op. cit.*, pp. 131–132.

as great or nearly as great in total fall and in rate of fall. Consequently run-off is large; floods are violent. The floods, less inhibited by the sparser vegetation on the flood plains, cut channels. As these channels deepen, the ground water of the flood plains is lowered and still sparser vegetation grows up.[24] The deepening and widening of channels is promoted.

It has been suggested by many students of the problem that these changes might be brought about not by a change in the total precipitation falling on the average each year, but by a change in its distribution.[25] This suggestion is ingenious. No one can deny that the present vegetation is adjusted not only to the low mean precipitation but also to the hazard of its irregularity. Each plant in the flora is adapted by some device to survive long and irregularly spaced intervals without rain. Every observer is also aware that the *año bueno,* the "good" year, when plants flourish and animals grow fat, is not necessarily the year of highest precipitation. It may be only average in total precipitation but the rains fall at intervals spaced so as to encourage each faltering leaf and stem to renewed and fruitful effort. The meteorological changes required to bring about such a regularization of the precipitation are, however, greater than those required to increase or diminish the total. Irregularity of rainfall within the year and from year to year, are the meteorological consequences of the inland position of the region. They are the result of continentality and operate in all areas more than 900 miles from the sea in all climatic zones. This factor of continentality is peculiarly effective in the area considered which lies halfway between the belt of the Monsoonal summer rains of the Gulf Coast on the east and the belt of Etesian winter rains of the California Coast on the west.

Other students have suggested that the climatic change is primarily one of temperature. A change to cooler temperatures would decrease evaporation and thus conserve the rainfall for the use of plants. A change to warm temperature would increase evaporation and make the same rainfall less efficient. These changes reflected in vegetational shifts would have much the same effect on the flow of streams as corresponding fluctuations in rainfall alone.

From a meteorological standpoint, it seems unlikely that a change in rainfall without a change in temperature would occur. There is, however, no agreement as to the linkage between temperatures and rainfall, particularly for the Southwest. In a broad way both rainfall and temperature are dependent on the wind system. Whatever general cause might increase

[24] Bryan, Kirk: Change in Plant Associations by Change in Groundwater Level, *Ecology,* vol. 9, pp. 474–478, 1928.

[25] Visher, S. S.: Climate and Geology (abstract), *Science, n.s.,* vol. 51, pp. 522–523, 1920.

velocities of the general wind movement would increase rainfall in the Southwest. As in a broad way wind movements are dependent on the pressure gradient from north to south, the times of ice advance—the climaxes of glaciation when general temperatures were presumably lower—were also periods of higher rainfall. That fluctuations in climate similar to those of the glacial period have continued down to our time is well-recognized. There are, however, many difficulties in getting accordant results. The evidence of climatic change in widely separated localities is diverse in kind. It is subject to alternate explanations. The bases of historical dating are of differing validity. In this maze of confusion it is difficult to steer a true course. Brooks[26] has charted a way but in each locality the difficulties remain.

In the Southwest the climatic hypothesis affords a plausible explanation of the physical facts. A slight change from the dry toward the less dry in climate is adequate to convert ephemeral streams from a condition of erosion to alluviation. Proof of the validity of the hypothesis lies in the demonstration that the events are synchronous from one stream system to another, and further, that the successive climatic pulsations fit all other attendant circumstances.

The question of synchroneity has been discussed. It appears that the next to the latest period of erosion (Table I) and the latest period of alluviation are events which succeeded each other between 1100 (presumably 1250) and 1400 A.D. in many widely separated localities. Much further work needs to be done in refining and making more precise the dates attributed to these events. Valid dates on the Rio Puerco and Zuñi River would be of prime importance. Many more local sequences of alluviation and erosion are possible. The present spirit of cooperation between archaeologists and geologists ensures that these additional data will be won.

The last epicycle of erosion, the present period of arroyo cutting, is quite adequately dated. In many localities local sources, surveyors' notes, and the memories of local inhabitants can be used to sharpen the historical record. These data will be valuable particularly in establishing on a more critical basis the influence of grazing on the initiation and development of the arroyo systems.

Whether the known periods of alluviation and erosion have a climatic cause or no, they must have had effects on the activities of the prehistoric inhabitants. These effects cannot be evaluated during the early episodes because of the imperfections of our knowledge. Too little is yet known either of the changes in the stream valleys or of the human events of that time.

The interval from 1100 A.D. to the present is, however, relatively well-

[26] Brooks, C. E. P.: *Climate through the Ages*, 1926.

known. The alternations of alluviation and erosion are well-dated. Knowledge can be refined and fortunate finds will from time to time yield more precise information. In this period also archaeology and history afford an outline picture of the life of the time. Thus the interrelation of the physical environment and human response can be analyzed.

FLUCTUATION IN PUEBLO PROSPERITY

The Pueblo area has been the scene of a long and intensive campaign of archaeological research. In spite of this great effort the ruins of the region are so numerous that only a very small percentage of the total has been excavated. Even the location of all the ruins is not yet known. Consequently at the moment a picture of the history of cultural development may be painted only as a sketch with broad and somewhat hazardous strokes of an imaginative brush. It is as yet impossible to make quantitative appraisals of the cultural stages even for small areas. One cannot yet say that the population was of a certain number at one time and thereafter decreased or increased, except in the most general terms. However, it is quite well established that the location of the people shifted throughout the period of occupation. Accompanying these shifts in location there may have been great losses in population. Morris[27] points out that the San Juan drainage and in particular the La Plata was the scene of the highest development of the Early Puebloan culture called Basketmaker II. In the succeeding cultural stage, Basketmaker III, development was also primarily located in the plateau area. Great changes took place in Pueblo I time, particularly in the introduction of a new people, new ideas, and in the practice of skull deformation. The occupied area may have been somewhat larger than before. The development of the civilization continued through Pueblo II stage to a climax in Pueblo III, the so-called Great Period. At this time the population was in part aggregated in great communities. The most notable ruins of the plateau area date from this time. As pointed out first by Kidder[28] the northern peripheral area in Utah and the eastern extensions in the Great Plains were abandoned at this time. There was, however, an extension to the south and every indication of flourishing prosperity in the areas occupied. The aggregation into great communities was not complete and many small or unit house sites were also occupied.[29]

Great changes occurred at the end of Pueblo III time. The San Juan area was abandoned. What appears to have been the homeland was de-

[27] Morris, E. H.: Archaeological Studies in the La Plata District, *etc.*, *Carnegie Inst. Wash. Publn. 519*, p. 11, 19, 29, 33, 35–36, 1939.

[28] Kidder, A. V.: *op. cit.*, pp. 126–127, and Fig. 25.

[29] Morris, E. H.: *op. cit.*, p. 41.

serted. Extensions of the population in the south and east were also lost and in immediately pre-Spanish time the total area occupied by the Pueblos was much diminished. There was, however, in the Hopi area, and presumably also in the Rio Grande area and in the southeastern quarter of Arizona, a great growth in population during the Pueblo IV stage. A few years ago many students of Southwestern archaeology held that these changes represented a great decrease in population, but this contention cannot now be supported. The available data would seem to indicate that the people who abandoned the San Juan area merely migrated. The increases in population in adjacent areas have not been estimated in any systematic way. When and if this desirable task is accomplished, it may be that an actual population loss will be established. The obvious and large population loss is post-Spanish. Large towns and villages reported by the Spanish explorers have been abandoned and existing villages have decreased in size.[30] Without doubt this deterioration is largely due to three new factors. New diseases were introduced. Raids by the hunting Indians equipped with newly acquired horses had greater effectiveness than before. Spanish oppression bore heavily on all the Pueblos and was particularly severe in certain villages, especially after the reconquest in 1692.

There remains for explanation the great disturbances and migrations at the close of Pueblo III time. Many great villages of the San Juan area were deserted, and excavation has shown that the desertion was on the whole orderly. Rooms were systematically cleared of easily movable goods. In places groups of pots or other obvious caches were carefully brought together and then apparently deserted. The last inhabitants are not found as abandoned skeletons in tumbledown rooms. Neatness and order prevailed up to the last moment. There is no evidence of a wasting of the population by starvation or disease. Morris[31] carefully considered the question of strife or peace in Pueblo III time. He shows that in the San Juan area, fires were less prevalent in Pueblo II and III time than in earlier periods. However, toward the close of Pueblo III time, fires became more frequent, but these fires occurred after easily removed contents had been taken out. Morris concludes that there was little pressure from the surrounding hunting tribes and that the fires and signs of violence are attributable to the internecine quarrels of the Pueblos.

The desertion of the Plateau area was early recognized and usually has been explained as due to the pressure by the surrounding hunting tribes. Morris's analysis effectively disposes of this contention. Even a cursory study of the military ineffectiveness of a hunting tribe should have brought

[30] Kidder, A. V.: *op. cit.*, Fig. 25.

[31] Morris, E. H.: *op. cit.*, pp. 41–42.

the same conclusion. Furthermore, a thoughtful reading of Casteñeda's sprightly account of the annual "siege" of Pecos, yields a vivid lesson in the ineffectiveness in siege warfare of hunters without a commissary. The "siege" was a prolonged armed truce for the purpose of trade.

Other explanations involve degenerative or epidemic diseases. Colton[32] has stated this thesis in its most precise form. He believes that the aggregation of people into the great villages of Pueblo III time brought to epidemic proportions diseases encouraged by lack of sanitation. Of these he mentions bacillary dysentery (summer complaint) which is today a scourge among the children of the Hopi villages. There is no proof that this disease existed in pre-Columbian time. Although Colton blames the use of rainwater pools, it is at present largely transmitted by the common housefly, *Musca domestica,* a Euro-Asiatic species that came into the Southwest with the domestic animals of the Spanish. There may have been similar diseases in pre-Columbian America, and they may have been encouraged by the crowding of people into large villages. There is, however, no available proof of their existence. Furthermore, equally large villages existed in Pueblo IV time in the Hopi Country and in the Rio Grande region. There is no indication that these people suffered from endemic or epidemic disease so much that the communities were weakened. In fact the early Spanish accounts imply that the first visitors found a singularly healthy and happy people. Epidemics have been disastrous to many villages since the Spanish conquest, but these plagues have been smallpox, measles, diphtheria, and other diseases introduced from Europe.

Douglass[33] has established on the basis of his tree ring studies that a great drought occurred in the Plateau area from 1276 to 1299 A.D. In the Rio Grande area the dry years began in 1269 and 1270, and there was a general intensification of drought conditions from 1276 to 1296 A.D.[34] Very naturally Douglass has proposed that this drought was the primary cause of the disturbances and shifts in population at the close of Pueblo III time. Such an explanation has obvious merit, as the Pueblos were an agricultural people to whom drought was a calamity.

There are, however, several circumstances which indicate that mere decrease of rainfall in the years 1276 to 1299 is not a complete explanation. The desertion of the Chaco canyon presumably occurred early in Pueblo III

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[32] Colton, H. S.: The Rise and Fall of the Prehistoric Population of Northern Arizona, *Science, n.s.,* vol. 84, pp. 337–343, 1936.

[33] Douglass, A. E.: Dating Pueblo Bonito and Other Ruins of the Southwest, *Natl. Geog. Soc. Pueblo Bonito Series,* no. 1, p. 49, 1935.

[34] Stallings, W. S. Jr.: Dates from Gallo Canyon, East Central New Mexico, *Tree Ring Bull.,* vol. 3, no. 1, p. 8, 1936.

time or by the year 1250, and thus slightly before the recorded drought. As a result of long drought, crop failures year after year would bring about famine. Famine implies that the people of whole villages and groups of villages would be weakened by starvation. Such groups would be too feeble and beaten in spirit to repair buildings or even to bury their dead. They could not have migrated and left their homes intact and neatly stripped of movable valuables. Yet excavation indicates that the deserted buildings were abandoned in this systematic way.

The effect of arroyo cutting is somewhat different from that of a mere drought. The growth of an arroyo takes place by the headward migration of falls. The steep new channel appears suddenly during a flood. It grows upstream in a chaos of fallen blocks, cliffs and minor channels. This falls section recedes a few feet or perhaps a mile each year, dependent on the number and size of the floods. As the falls move upstream, flood-water field after flood-water field becomes useless. There is, however, warning in advance and the cultivator knows that this year or at least within a few years calamity will overtake him.

This relatively slow process would be cushioned by the social organization of a Pueblo people. From our knowledge of this organization, it is possible to outline the successive steps by which a Pueblo village would react to the progressive development of this menace to its existence. The fields are divided among the clans or family groups and cultivated by the unmarried boys and the husbands of the clan sisters. If then a field is destroyed, the clan or group must seek a new field, but the other clans and groups are not impoverished except by such charity as they may voluntarily bestow. The clan or group usually has other fields, and labor would be concentrated in these other fields or in new fields in the general locality. As an individual may cultivate fields as far as 30 miles from his home, the choice of areas for cultivation is large. If, however, arroyo cutting were general in the area, the impoverished group would probably seek relief in the use of lands of similar groups in distant but related villages. Gradually over a term of years the clan or groups would move to the distant location.

As the arroyos grew, other groups would lose their land at intervals of one or several years. These groups in turn would seek new fields, first nearby, and then finally in distant areas. Each group as a self-supporting unit of the whole community would be divided into those retaining the old home, and those in the new. Those remaining in the old village, carefully preserving their portion of it and utilizing its every valuable article, would finally remove to the new. Thus the deserted village would on excavation by the modern archaeologist have that neat and orderly air commented on by every observer.

It seems likely also that for a very considerable period the old home would form a winter gathering place for the dispersed groups who would return for a season of ceremony. Thus, at present, the majority of the Acomas farm and reside at Acomita, but return for a part or the whole of the winter to Acoma. A new church recently built at Acomita may be taken as a sign that this return, dictated by the ancient religion, is not supported by the new. It is a safe prediction that before many years "Old" Acoma will be only an outlying cattle and sheep ranch of the "new" Acomita.

That lack of rainfall was the cause of the cutting of arroyos seems on general grounds reasonable. The drought recorded in the tree rings appears to have been merely the climax of a long period of dryness. In such periods of aridity, the practice of flood-water farming has many advantages. Even small rains properly spaced afford good crops. The probable response of the Pueblo communities to a prolonged series of dry years would be to plant more fields at great distances apart so as to increase the chance of fortunate rains. But if a general period of arroyo-cutting accompanies a period of drought, the sites of fields would be destroyed and migration would be forced. The effect of arroyo-cutting on agriculture is, however, much more severe in some localities than in others. Thus the canyons of the Plateau area have relatively narrow flood plains built up of relatively clayey alluvium. Here the cutting of an arroyo is completed rapidly and nearly all the available farming land is destroyed. Such a locality is Chaco Canyon where, in its present state of dissection, even the side canyons are ruined and no longer valuable.

The Hopi country is a remarkable exception within the Plateau area. Here the prevalence of wind-blown sand inhibits complete dissection. In the present cycle of dissection many minor streams are unaffected and their flood plains are available for farming. Furthermore, sand dune agriculture is important, and Hack[35] has demonstrated that there was little change in the area of available farmland in periods of dissection.

In the Rio Grande area, the diversion of living water for irrigation is possible at many localities. Apparently this type of farming was practiced increasingly in the later periods of Pueblo life. Even in this region flood-water farming was important; for the Tano people could have farmed their homeland in the drainage of the Rio Galisteo[36] in no other way.

The great migrations of 1300 to 1400 A.D. are thus explained by the synchronous period of erosion, which was presumably induced by a climatic swing to dryer conditions. This fluctuation toward the dry appears to have

[35] Hack, John T.: The Physical Basis of Hopi Agriculture, *cit.*

[36] Nelson, N. C.: Pueblo Ruins of the Galisteo Basin, N. M., *Amer. Mus. Nat. Hist. Anthrop. Papers,* vol. 15, Pt. I, 124 pp., 1914.

reached its climax in the great drought of the latter part of the 13th century. The response of the Pueblo to climatic stress is not obvious in the archaeological record. It must be inferred from the movements of people and from the anthropological probabilities.

The response to the cutting of arroyos and the loss of flood-water fields was a complex phenomenon in which the social structure of the Pueblos played a rôle in mitigating the immediate effect. Their village communities were, however, forced into new areas and into a more extensive use of living water as a means of irrigation. These changes we now perceive but vaguely. In the future, assuming the present rate of archaeological progress, we shall know what each community did, and where it went, and we shall have a depth of understanding, now denied us, of the response of man to a changing world.

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January, 1941.

An Ethno-Telephonic Survey of French Louisiana

PEVERIL MEIGS 3rd

The Louisiana French, with distinctive language and culture, number more than half a million whites[1] and additional thousands of negroes. Surprisingly, the significant culture region of French Louisiana does not appear to have been delimited in detail upon a map hitherto. The United States Census does not include direct evidence of the French element of the population. Census statistics on foreign ancestry go back only one generation and therefore do not distinguish the present Louisiana French, whose ancestors began to settle in Louisiana from 175 to 225 years ago. The present paper is therefore a pioneer attempt to find and apply a quantitative basis for delimiting French Louisiana.

PROCEDURE

In the belief that the occurrence of French names would be a valid basis for mapping the distribution of the Louisiana French, I made a regional analysis of names in the telephone directories of 1939. Directories were assembled from 115 Louisiana and 6 nearby Texas communities, including all exchanges of the regular Bell system of Louisiana and 18 exchanges of local telephone companies.[2] The accompanying map shows the distribution of the directories used. Only 8 of the state's 64 parishes, chiefly at the northern and southern margins, have no telephone directories.

To avoid the necessity of tabulating all the names in the directories, a sampling method was used. The ten most common names (constituting about 10% of all names) in each directory were listed, the percentage of French names in each list was calculated, and the resulting ratios were plotted on a base map. Tabulations of names in representative directories

[1] Smith, T. Lynn: The Population of Louisiana: Its Composition and Changes, *Louisiana State University Bulletin No. 293,* November, 1937, p. 18.

[2] Thanks are due the School of Geology, Louisiana State University, for financial and secretarial help in assembling the directories; Southern Bell Telephone and Telegraph Company for a list of the independent companies; Dr. V. J. Parenton, Louisiana State University, for checking the completed paper against his lifelong knowledge of his native French Louisiana; and the National Youth Administration for providing students to do the tedious work of counting names. The tabulations were checked by the tabulator and sample-checked by the writer.

showed that the lists of ten contained about the same proportion of French names as the entire directories. A check of pupils' names in a representative school district (Jennings) showed that the school rolls contained the same proportion of French names as the telephone directory. Thus the sampling method here used gives an accurate estimate of the proportion of French in the various communities.

In two critical marginal areas where telephone service and hence directories were lacking, estimates of French percentages were made by field count of rural mailboxes and store signs. In the area southeast of Baton Rouge, for example, a winding drive of 150 miles back and forth across the border of the French area permitted examination of 544 mailboxes, of which 159 bore legible names. Morphological distinctions between Anglo-Saxon and homemade French mailboxes also proved helpful in mapping the line. The French "boxes" usually consisted of a piece of tin arched over a small wooden platform and nailed to the platform along two sides.

Upon the map, areas of similar ranges of ratios of French names were delimited and shaded (Fig. 1).

RESULTS

The resulting map shows a distinct coherent area with high ratios of French names in southern and central Louisiana. Extending northwest 160 miles from the Gulf of Mexico is a sizable core in which *all* names on the lists are French. East of this core is a large strip where French names constitute more than 75% of all listed names. Beyond the ratio boundary[3] of 50% (shown on the map by a heavy line) there are comparatively few French names. Transition from the high percentage French area to 100% non-French areas is ordinarily abrupt. The ratio boundary of 50% is suggested as an approximate limit for French Louisiana.[4]

The largest contiguous zone with significant French elements beyond the 50% ratio boundary occurs in the southwestern prairies, where non-French settlers immigrated from the Corn Belt some 50 years ago. Within this "twilight zone," the situation is complex, with some districts strongly French, others strongly Anglo-Saxon or German, and others mixed. These finer areal distinctions cannot be determined from the telephone directories.

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[3] Since the ratios apply to telephone exchange *areas* rather than to points, and since the changes in ratio from area to area are not usually gradual, the ratio boundaries should probably not be called "isopleths" in the strictest sense of the word. They partake more of the character of smoothed choropleths, or perhaps dasymetric lines.

[4] The use of a lower ratio would affect the boundary of French Louisiana very little except in the southwest, where the intrusive lobe of less than 50% French would be thrown into the French area.

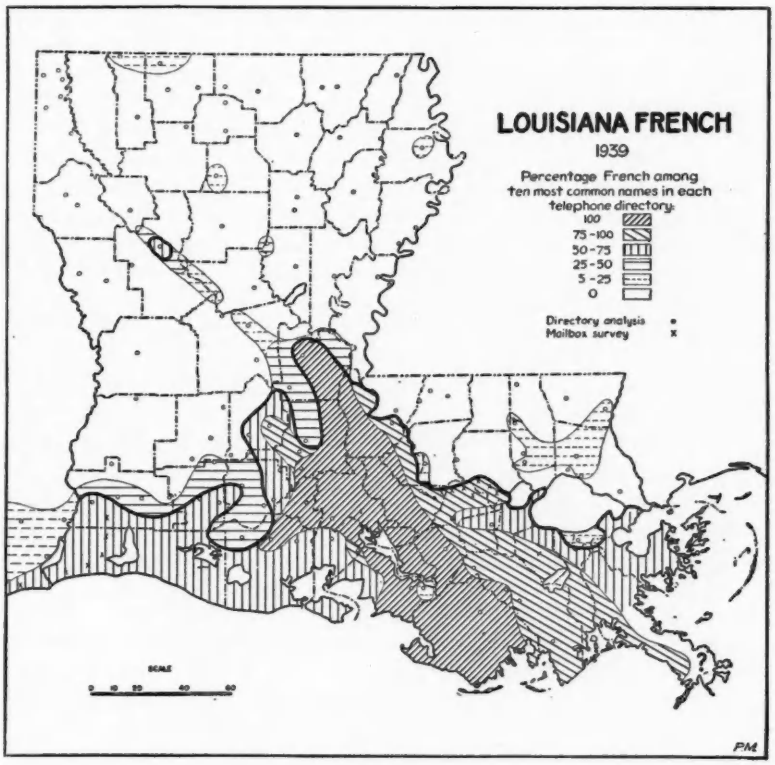

FIG. 1.

The principal French offshoot to a neighboring state reaches into Texas, where cities as large as Beaumont and Port Arthur have two Louisiana French names among the leading ten in the directories. The French element has not reached Galveston, and is represented only weakly in Houston. The people of some communities near Mobile Bay in southern Alabama call themselves "Creoles" and "Cajuns," but French language and traditions, if they ever existed there, do so no longer. Even French names are rare, and a check of school rolls of one of these "Cajun" communities showed not a single family name indicating Latin derivation.[5]

French Louisiana as here delimited is approximately coextensive with the

[5] Bond, Horace Mann: Two Racial Islands in Alabama, *American Journal of Sociology*, January, 1931, pp. 552–567.

southern Mississippi and Red River delta, floodplains, and lower terrace, the coastal marshlands, and, in spots, the southwestern prairie. Economic districts included within French Louisiana are the south central "sugar bowl," much of the southwestern rice, cattle, and cotton district, the trapping, fishing, and swamp lumbering areas, and part of the cotton district in the north.

In the Anglo-Saxon "sea" beyond the main French area are several small "islands" where French names occur but where French language and culture have largely disappeared. The most important of these islands is Natchitoches: the first permanent French colony in Louisiana. The leading French names of Natchitoches do not appear upon the lists of other Louisiana communities. At least one Anglo-Saxon community has developed in the main French area, at Morgan City. The two large Mississippi River cities at the eastern edge of French Louisiana are now predominantly Anglo-Saxon. New Orleans has only one French name among the leading ten in the telephone directory; Baton Rouge, three. The student directory of Louisiana State University, with names from all parts of the state, has two French names among the leading ten: LeBlanc and Broussard.

The validity of the limits shown on the map was confirmed by interviews in the field, both with ordinary residents and with scientific workers in various parts of the state.

COMPARISON WITH PREVIOUS STUDIES

Mention should be made of two previous studies which have dealt with the delimitation of French Louisiana.

T. Lynn Smith[6] gives a careful description of the French boundary on the basis of percentage of Catholics and of negroes in the population, presence or absence of towns and cities and of non-French Catholics, personal data from students of Louisiana State University, and facts gained from field trips. He describes the French area as resembling a triangle based upon the Gulf of Mexico, with the apex at the confluence of the Red and Mississippi Rivers, one side running to the southwest tip of the state, the other through New Orleans to the Gulf. He mentions also the scattered French-settled communities along the Red River as far as Natchitoches. Figure 2 reveals a close positive correlation between Smith's conventionalized composite boundary and my detailed telephonic boundary, with largest differences apearing in the mid-sections of the two sides of the triangle.

In 1940 there was published what appears at first glance to include an actual map of French Louisiana. On the map of "Rural Cultural Regions in the United States," scale 1/5,000,000, prepared under the direction of T. J. Woofter, Jr., for the Bureau of Agricultural Economics, Region 25 is

[6] *Op. cit.*, p. 17.

labelled "French Louisiana." It will be apparent from Figure 2 that Woofter's boundary differs widely from Smith's and mine in two sectors. It omits from French Louisiana the two northern parishes which we include, and it includes a large section east of Baton Rouge which we exclude.

In seeking to explain the discrepancies, I found that the Woofter boundary was derived from a small-scale map of Rural Cultural Regions contained in a research study by A. R. Mangus.[7] Region 25 on the Mangus map is entitled "Southern Louisiana." Apparently Woofter changed the name to "French Louisiana" when the map was redrawn. The change of name was unfortunate, for Mangus did not use any actual indicator of the

FIG. 2.

[7] Rural Regions of the United States, *Work Project Administration, Division of Research*, 1940, Figure 2.

presence of French people in drawing his boundary. Ten quantitative cultural indices were used in the delimitations. The four major indices characterize Southern Louisiana as having a very low plane of living, very low percentage of people on relief in 1934–1935, large number of children per 1000 women, and high infant mortality.[8] Mangus mentions in his text that Southern Louisiana contains many French descendants with French culture, but he does not claim to have used any French factor in the delimitation. The cultural boundary as drawn may be satisfactory for Southern Louisiana, for which it was originally intended, but "French Louisiana" is a misnomer for that region.

In passing, it should be remarked that the Mangus study appears to be an original and thought-provoking contribution to the culturo-regional geography of the United States, both as to the quantitative method of regional definition and as to the locations of the regional boundaries.

SECONDARY TELEPHONIC DATA FOR FRENCH LOUISIANA

An analysis of telephone directories sheds light not only upon the problem of delimiting French Louisiana but also upon problems of internal distributions.

The distinction between the earliest French-speaking immigrants, who began to settle in Louisiana in the first quarter of the 18th century, and the later comers, who had been expelled from Nova Scotia or Acadia by the British fifty years later, is important in history and perhaps in culture. For the purposes of this paper, descendants of the first group may be called Creoles;[9] of the second group, Acadians or "Cajuns." In an attempt to determine the relative numbers and regional distribution of these two French cultural strains, a check was made to determine which names in the lists from current directories appeared also in lists of 207 names mentioned by Dudley LeBlanc[10] as having been present in Acadia before the expulsion. The directory lists from within the main coherent area of French in Louisiana were found to contain 41 Acadian names, totalling 1002 individuals, and 79 other French names, of 587 individuals: a proportion that agrees closely with the local opinion that about two-thirds of the Louisiana French are of Acadian ancestry. The twelve leading French names from the directory lists were as follows, in order of their numerical importance:

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[8] *Op. cit.*, Table 5; p. 43.

[9] This restricted sense of the term "Creole" is in common use in French Louisiana. A more common hemispheric usage applies the term to all native American whites of French or Spanish ancestry. Many other definitions, some more and some less restricting, are used by various writers.

[10] *The True Story of the Acadians*, 1932.

LeBlanc (A)
Landry (A)
Hebert (A)
Broussard (A)

Boudreaux (A)
Mouton (A)
Richard (A)
Bernard (C)

Gremillion (C)
Toups (G)
Fontenot (C)
Martin (A)

(A) Acadian

(C) Creole

(G) Latinized German[11]

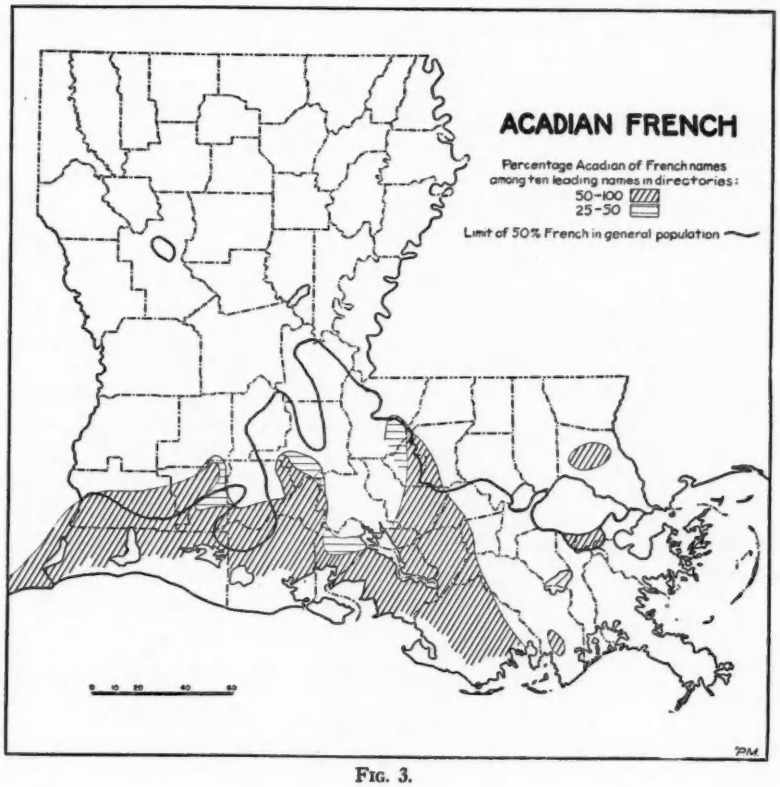
ACADIAN FRENCH
Percentage Acadian of French names among ten leading names in directories:
50-100
25-50
Limit of 50% French in general population

FIG. 3.

The percentage of known Acadian names among the French names was calculated for each directory list, and the ratios were mapped (Fig. 3). This map shows that there are coherent areas where Acadians predominate among the French population, and other, lesser areas where Creoles prevail. The validity of the distributions shown by the map is confirmed by the known locations of some of the historic nuclei of original Acadian settlements. A map of French dialectic differences should give interesting confirmation to Figure 3. A striking feature of the map is the abruptness of transition from Acadian to Creole areas.

ADDITIONAL PROBLEMS

Besides their use in mapping existing distributions, telephone directories can be used in detecting trends. Detailed comparisons of name-ratios at intervals of ten years, for example, would show whether the proportion of French is increasing or decreasing, and in what border sectors the proportion is increasing, shrinking, or static.

Another subject needing investigation is the extent to which the cultural landscape is correlated with French occupance. Such traits as French language, Catholic religion, and distinctive food habits have been used to differentiate between French and non-French portions of Louisiana. These traits are of great diagnostic value as indicators and unifiers of culture, but they do not themselves constitute elements of the landscape.

State College, Chico, California.
January, 1941.

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[11] The name "Toups" goes back to Caspar "Dubs," who came to Louisiana from Zurich, Switzerland, according to the exhaustive monograph by J. Hanno Deiler: The Settlement of the German Coast of Louisiana and the Creoles of German Descent, Philadelphia, 1909. The methods of Deiler are accepted by T. Lynn Smith and Vernon J. Parenton: Acculturation among the Louisiana French, *The American Journal of Sociology*, 1938, p. 358, with the statement that Deiler has "demonstrated beyond all doubt" the German origin of many well-known Louisiana "French" names, such as Toups.

In many parts of the United States such names as Bernard, Martin, and Richard might be either French or English. In French Louisiana, however, field surveys and check of the given names in the telephone directories show these names to be French in every community where they appear on the list of the leading ten names.

Melbourne as a Functional Center

CLIFFORD M. ZIERER

Melbourne's undisputed position as the chief manufactural and commercial city of Victoria and its approximately coördinate rank with Sydney in those respects bear significant relationships to facts of general location and site. Numerous phases of its developmental sequence as well as its present day functional attributes are clearly shown in the existing urban forms. Many elements of its urban pattern are also closely related in their character and in their areal arrangements to significant features of the physical site.

With more than a million inhabitants, Melbourne includes within its metropolitan limits more than half the population of Victoria. The proportion of the state's inhabitants living in the capital city has increased steadily from decade to decade and Victoria ranks first among the Australian states in that respect. Owing to the relatively high population density of Victoria Melbourne is situated at the point of intimate focus for considerably more than one-fourth the population of the entire Commonwealth.

Melbourne has strongly affected the economic, social, and political life of Victoria and it is in large degree representative of the mode of life of all urban residents of that state. The Australian is an urban dweller to a far greater extent than is realized by most persons of other continents who are likely to regard the "typical" Australian as a lonely shepherd or a wheat farmer of the interior plains. Even a brief interpretation of the location, form, and function of Melbourne will thus assist in an understanding of the urban way-of-life which has attracted nearly two-thirds of the population of the whole of Australia.

MELBOURNE'S LOCATION AND SITE

Melbourne occupies a strategic maritime position near the southeast corner of Australia midway between Sydney and Adelaide. The wide spacing of the capital ports at intervals of about 500 miles helps to guarantee for each city large sections of the coastwise trade as well as the trade from large portions of the interior. Melbourne's focal position gives it particular advantage in the important commerce between the mainland and Tasmania and New Zealand. Easy access to Europe, America, and the Orient may similarly be claimed. Only Sydney enjoys a somewhat greater trade, which

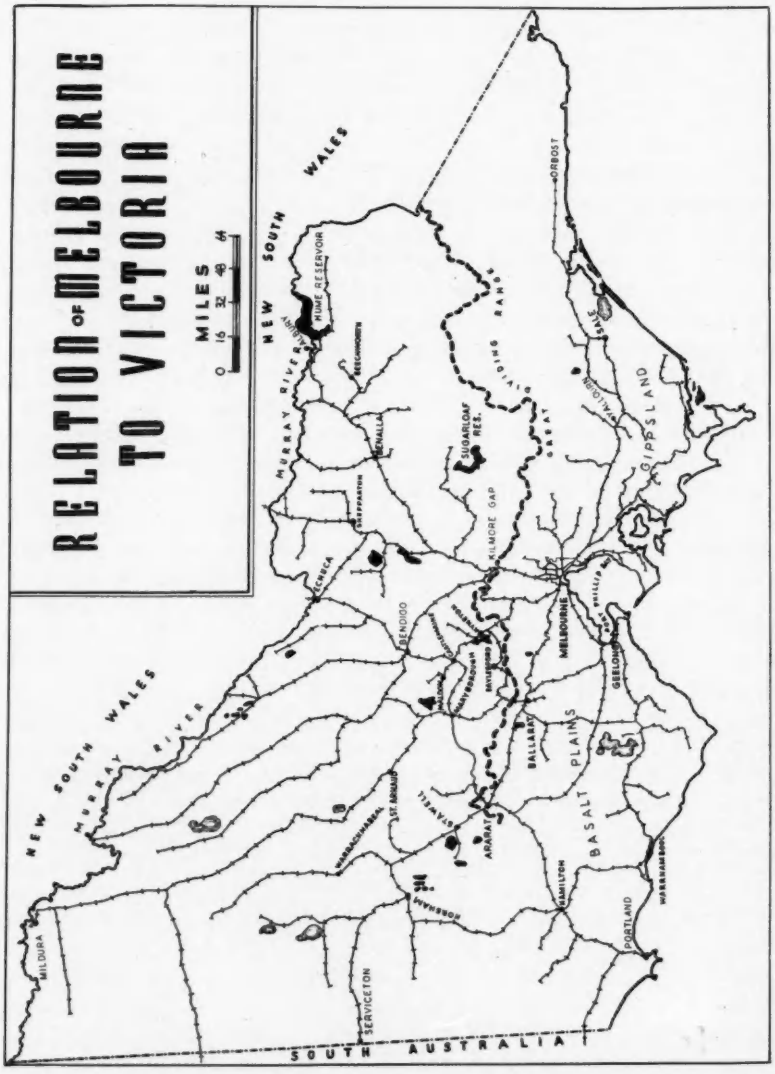

FIG. 1.—Melbourne, by reason of its deeply indented and central position along the Victoria coastline, serves as the logical outlet for the produce of most of that state.

fact may be explained largely by the greater size and productivity of New South Wales

Situated at the head of Port Phillip Bay, Melbourne is at the approximate center of the important east-west extending coastal lowland of Victoria (Fig. 1). The Gippsland District, with its heterogeneous mixture of plains and hill areas, extends for more than 150 miles to the east of Melbourne while the basalt plains and fringing coastal areas of the Western District reach almost as far as the South Australian border.[1] Lying astride the boundary between those contrasting physiographic regions Melbourne's east and west suburbs display notable differentiations in the matter of land forms as well as in certain engendered cultural development.

A considerable portion of the Victoria lowland to the south of Melbourne, including Port Phillip Bay, has been submerged. Those portions of the lowland remaining above sea level and fringing the northerly margins of the bay afford a site which has proved favorable to important urban development. The deeply indented character of Port Phillip Bay places Melbourne in close proximity to the productive regions of the state and affords it ample protection from the open ocean to the south.

About 35 miles to the north of Melbourne the east-west Dividing Range "shuts off" the coastal districts from the lowlands of the Murray River but its diminishing height toward the west reduces the barrier effect between Melbourne and the Murray Basin. Fortunately, also, the especially low Kilmore Gap (elevation 1,145 feet) lies directly north of Melbourne and it affords an easy railway route to the interior plains as well as to Albury and Sydney. Railways penetrating the Murray Basin to the west of Kilmore Gap cross the broad unimpressive Dividing Range at elevations of 1,800–2,000 feet without appreciable difficulty.[2] Melbourne thus lies at the focus of the railway system for the whole of Victoria and it has several connections with the railway systems of South Australia and New South Wales. The hinterland of Melbourne coincides in general with the limits of Victoria. Small portions of southwest New South Wales, however, have been tapped by the Victoria railway system and they look to Melbourne rather than to Sydney for trading connections.

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[1] Hills, E. S.: Physiography, *Handbook for Victoria,* Aust. and N.Z. Assn. Adv. Sci., Melbourne, 1935, pp. 78–89.

[2] The importance as a barrier of the so-called Dividing Range, paralleling the entire east coast of Australia, is commonly over-estimated, as has been pointed out by others. Except where elevated and extensive masses of granite or basalt occur the divide is in many places but little more than a water parting. (Taylor, Griffith: The Physical and General Geography of Australia, *Federal Handbook,* 84th Meeting British Assn. Sci. (Australia), 1914, pp. 89–103.)

An examination of the local topography of the Melbourne site affords many clues which help to explain the more detailed character of the city's development (Fig. 2). A belt of lowland from one to three miles wide and

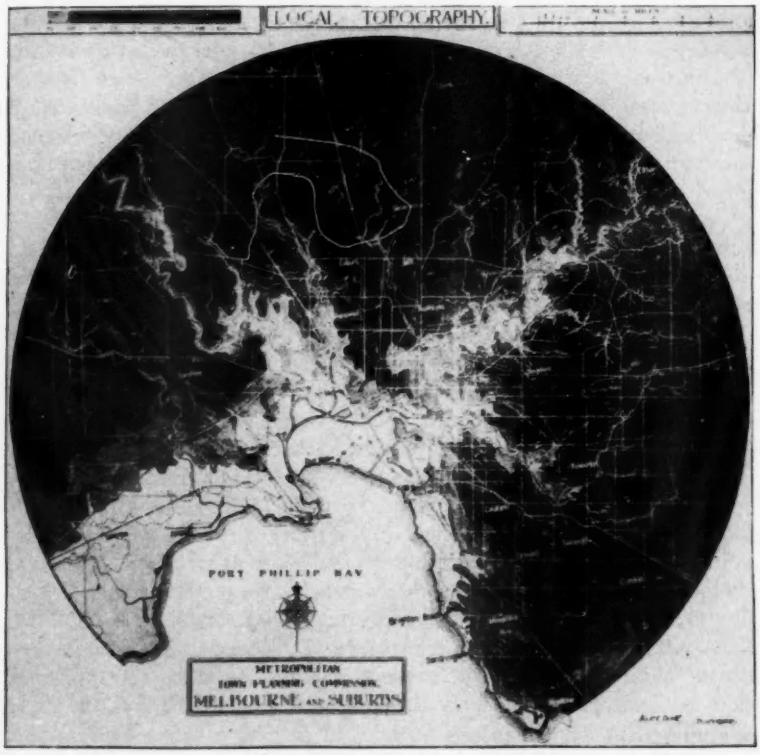


FIG. 2.—The amphitheatre in which Melbourne has developed is here illustrated. The radial stream valleys focusing upon the central city and the contrast in topographic forms between the eastern and western suburbs are clearly shown. The section illustrated has a radius of 13 miles drawn from the city center and it is commonly regarded as the metropolitan area. The 25-foot contour is shown but all other contours are drawn at 50-foot intervals above sea level. (Map from the Metropolitan Town Planning Commission.)

less than 50 feet above sea level fringes the head of Port Phillip Bay, or Hobsons Bay as that portion is identified. Much of the lowland consists of the combined deltas of the Yarra and Maribyrnong rivers and lesser streams which focus upon the head of the bay. Narrow tongues of alluvium

of similar elevation extend inland for several miles along the half dozen well-defined radial stream courses. Within a 13-mile radius of the central city, land surfaces rise gradually to heights of 200–300 feet on the west and to heights of 300–400 feet on the north and east, thus forming a sort of amphitheatre in which the city has developed. About 35 miles to the north of Melbourne the outer rim of the basin is formed by the Dividing Range.

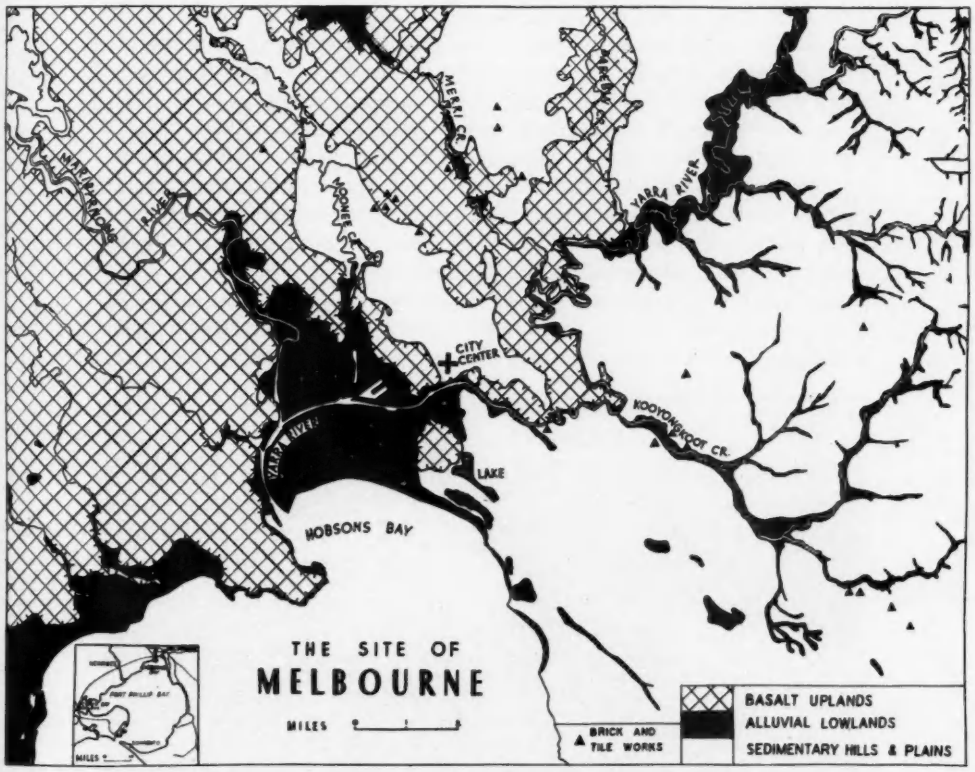


FIG. 3.—Local land forms and soils differ notably on the western basalt (Pliocene) uplands, on the diversified older sedimentary area to the east, and on the recent alluvial deposits along stream courses and bay margins. The close adjustment of the course of the Yarra River to the margin of the basalt flow is noteworthy. At one time it discharged into the bay through the small lake shown to the south of the city center. Most of the area shown on this map is occupied by the present city. The small inset map shows the general relation of Melbourne to the whole of Port Phillip Bay. (Adapted from map of Victoria Department of Mines.)

The entire pattern of city life clearly focusses upon the lowland margins at the head of Port Phillip Bay.

The western and northern suburbs of Melbourne spread over the slightly undulating surface of the basalt plain, the continuity of which is broken by the stream valleys cut into the resistant material (Fig. 3). The local portions of the basalt district are known as the Keilor and Werribee plains from the townsites and shires which occupy portions of their surfaces.[3] Bed rock is commonly exposed along the steep margins of the stream valleys but thin layers of tenacious chocolate-colored soils cover the upland surfaces of the basalt flows. Loose blocks of basalt are scattered over many parts of the plain, and in places they are so numerous as to discourage urban occupation or any attempts at agriculture. In many places walls or "dikes" have been constructed about the margins of properties from loose blocks collected from field surfaces. Scores of quarries produce basalt (known locally as "bluestone") for construction purposes. The tough and resistant character of the crushed bluestone makes it especially desirable for highway building and for railway ballast as well as for cut-stone.

Owing to the shallow soil and the impervious character of the unaltered basalt a steppe-like growth of short grasses and herbs is the characteristic vegetation cover of the western plain (Fig. 4). With less than 25 inches

FIG. 4.—The lower Maribyrnong River has cut a relatively wide valley through the basalt layers of the western suburbs. The level upland surface is characteristic of the basalt plains and it is covered with grasses and occasional small trees.

[3] Hall, T. S.: *Victorian Hill and Dale—A Series of Geological Rambles*, Melbourne, 1911, pp. 19–20.

of rainfall and with limited storage capacity in the soil, periods of water shortage frequently occur and xerophytism is characteristic of many species.[4] While only occasional stunted trees appear on the upland surface, tree growth is common along stream courses.

To the east of Port Phillip Bay extends the Gippsland District, an extensive region of interspersed valleys and hill areas (Figs. 1, 2, and 3). Encroaching upon the margin of that physiographic province the eastern and southeastern suburbs of Melbourne penetrate an area of diversified sedimentary rocks which have been eroded into a picturesque and varied relief especially attractive for residential use. Soils are deep and easily cultivated and rainfall amounts to 30 inches or more.[5] Scattered orchards and gardens are characteristic of the eastern suburban margins in contrast to their notable absence on the basalt plain. In areas of sandy soils especially to the southeast a scrub heath is the characteristic native vegetation. On the heavier soils forests of eucalyptus occur and their size and density increase notably with elevation. In the Dandenong Range, 20 miles east of Melbourne, where an elevation of 2,000 feet is attained, dense growths of giant eucalyptus (*Eucalyptus regnans*) occur and tree-ferns fill the moist gullies (Fig. 5). That district is included in the so-called Eastern Highlands which lie to the northeast of Melbourne and border the Gippsland along its entire northern side.

Abundant room is available on all sides of Melbourne for urban expansion but the greater physical attractions of the east side have caused the city to grow principally in that direction. Varied topography, cultivable soils, scattered native trees, and ready accessibility are factors encouraging city expansion upon the areas underlain by sedimentary strata.

DEVELOPMENT OF URBAN OUTLINES

The spread of urban forms in Melbourne is related closely to major physical features such as bay outline, stream courses, degree of slope, character of underlying rocks and soil, and drainage condition. The selection of Melbourne's site and the development of its cultural forms, however, also reflect the arbitrary judgment and preference of the founders and of the many persons who later directed or contributed to the expansion of the

[4] Patton, R. T.: Flora of Victoria, *Handbook for Victoria, cit.*, pp. 54–65.

[5] The average annual rainfall received in central Melbourne is between 25 and 26 inches well distributed throughout the year. The mean monthly temperature varies from a minimum of 41.9° F. in July to a maximum of 78° F. in January. Prevailing wind directions during the summer months are SW–SE and during the winter months NW–NE. The average annual amount of evaporation is 39 inches. Only on occasional summer days does the temperature rise above 100° F. while freezing temperatures occur as infrequently on winter nights. Snow very seldom falls within the occupied city area. (Data from *Official Yearbook of the Commonwealth of Australia.*)

FIG. 5.—While the eucalyptus forest of the rugged Dandenongs is dense and tall, as illustrated along this mountain-side road, the cover of the eastern hilly suburban margins is relatively open and trees spread out horizontally instead of rising to great heights.

numerous types of urban expression. The development of the subdivision and communication patterns of Melbourne has proceeded in close association in a functional manner with the successive types of land use during the period of modern occupation.

Following the unsuccessful attempt of David Collins, in 1803, to form a penal settlement at Sorrento (Fig. 3, Inset Map), on the barren sandy peninsula near the entrance to Port Phillip Bay, more than thirty years elapsed before Melbourne was finally established. Even at that time the initiative came not from official Sydney, the source of many Australian settlements, but from Tasmania where the shortage of good pasturage was already felt. Early pastoral occupation in Victoria focused in part upon the northern and western-most reaches of Port Phillip Bay from which points the extensive natural grasslands of the basalt plains could be reached. Thus Melbourne and Geelong came into being at about the same time (Fig. 1).

The original informal settlement at Melbourne was made in 1835 at a

point on the Yarra River beyond which small sea-going vessels were unable to proceed. The site was on well-wooded, rising ground readily accessible to an abundant supply of fresh water in the Yarra. In 1837, the settlement was formally laid out by government surveyors and lands were offered for sale[6] (Fig. 6). Williamstown was laid out at the mouth of the Yarra at

FIG. 6.—Melbourne in 1840. Melbourne was established at that point on the Yarra River where it cut through an old flow of volcanic rock and beyond which small ocean vessels could not proceed (*cf.* Fig. 3). That point also coincided with a tract of land rising gradually from the water's edge and regarded as suitable for a town site. Fresh water was obtainable from the river beginning at that point and ample supplies of timber were available. (Courtesy of the Public Library of Victoria.)

the same time and it was regarded by certain officials as the better site since it was accessible directly from Hobsons Bay. Geelong was officially surveyed and named as the third center of settlement on Port Phillip Bay and it likewise had its advocates among the early arrivals.[7] The difficulty of obtaining a satisfactory fresh water supply at Williamstown and the bar across the entrance to Geelong harbor, however, directed settlement to Melbourne despite the difficulty of navigating the shallow and devious course of the lower Yarra.

The first survey at Melbourne involved a rectangular tract about a mile long (parallel to the Yarra) and a half mile wide (Fig. 7). Blocks were laid out ten chains on the side and one and one-half chains were allowed for streets, although one chain (66 feet) was regarded as the standard width in most towns at the time. Narrow lanes of one-half chain width were cut through the centers of all blocks in the direction of the main northeast-southwest axis of the town. The lanes were intended only to give rear access to the half-acre properties fronting on the principal streets. That original townsite with small addition to its width comprises the present commercial core of the city.

[6] Westgarth, W.: *Victoria,* Edinburgh, 1853, pp. 58–66. A reproduction of the first map of Melbourne (1837) surveyed and drawn by Robert Russell may be seen in Selby, Isaac: *The Old Pioneers' Memorial History of Melbourne,* 1924, p. VI. A map of the organized settlement as of 1838 is shown on p. 72.

[7] Westgarth, W.: *Victoria and the Australian Gold Mines in 1857,* London, 1857, pp. 87–8.

FIG. 7.—Map of Melbourne in 1853. The original subdivision at Melbourne is shown by the mile-long rectangular tract paralleling the north bank of the Yarra. The early expansion of the city along main routes of travel to the northwest and north is shown, as well as expansion to the east and southeast where attractive residential sites were available. Important growth in the direction of Hobsons Bay (South Melbourne) is also indicated. The early stages in the development of the formal rectangular pattern (oriented with respect to the cardinal directions) and the extensive park system are shown. (Courtesy of the Metropolitan Town Planning Commission.)

Melbourne was laid out to serve the needs of a pastoral community. Following the establishment of the original town plat, government surveyors proceeded to block out large pastoral holdings on a rectangular grid oriented to the cardinal directions and paying little or no attention to natural features. Although most country roads were provided with a width of one chain, the rectangular pattern was interrupted in places by diagonal stock routes or roadways having a width of three chains. Some of the latter had been located approximately by the first settlers in bringing their stock and produce to the Melbourne market. The abnormal width allotted to the stock routes provided some grazing for animals en route to market in addition to a roadway for the weaving bullock teams. Stock routes afford one of the characteristic elements of the transportation pattern throughout rural Australia and many of them focus upon the market centers. Although portions of the three-chain roadways within the metropolitan district were later narrowed by local municipal authorities, these diagonal stock routes furnished the bases for a number of Melbourne's most attractive and convenient modern boulevards.

Although the original surveyors had no concept of the ultimate large expansion of Melbourne the basic lines of the first land survey are fundamental in the present metropolitan street plan (Fig. 7). As settlement expanded many pastoral holdings were successively subdivided into farms, orchards, market gardens and, finally, into city lots. Each parcel of land was subdivided according to the wishes and judgment of the owner. Thus, although the individual parcels show great diversity in subdivision details, with many secondary streets failing to join with those in adjacent tracts, the principal through streets usually stretch for miles across the city area along the lines of the official survey grid.

While Melbourne had grown rapidly under the influence of pastoral occupation, its growth became explosive following its selection as the capital of the new state of Victoria and following the discovery of gold at Ballarat, Bendigo, and Castlemaine in 1851 (Fig. 1). At the Census of March 1851 Melbourne's population was about 20,000 persons. By the time the gold fever had subsided, some five years later, it amounted to about 100,000. For more than forty years thereafter Melbourne ranked as the first city of Australia.

Even before the gold rush took place land adjacent to the original townsite was being subdivided. During the 1850's most of these inner suburbs were largely occupied[8] (Fig. 7). Heavy traffic along the road to the gold

[8] Grimwade, W. R.: *Victoria—The First Century*, Melbourne, 1934, pp. 149–151, 197–9.

fields led to the early establishment of outlying suburbs to the northwest. In similar manner suburban settlement took place along the Sydney Road to the north. Seaside watering places sprang up along the east margin of Port Phillip Bay for a distance of fifteen miles. Fashionable residential suburbs also appeared on the higher eastern bank of the Yarra River during the 1850's.

Another major factor contributing variety to Melbourne's somewhat prosaic rectangular street pattern is the series of radial stream valleys which converge near the central city (Fig. 2). In most places the streams are sufficiently entrenched and the valley sides so abrupt that travel at right angles to their courses involves difficulties or may be impracticable. In consequence many through streets have been adjusted locally to the direction of stream valleys and innumerable minor streets terminate abruptly at the upland margins. The notably winding character of portions of the valleys makes the local street pattern chaotic in places.

Contrast in political responsibility contributed further to the discontinuity of street pattern along the stream valleys. Nearly everywhere along their courses the more deeply entrenched channels form the boundaries between the many local municipalities. The unoccupied character of many of the valley bottoms facilitated the later connection via bridges and fills of selected upland streets. Although early roads avoided the radial stream valleys the latter now afford opportunities for the construction of through highways to relieve congestion on upland arteries.

Railways also provide irregularities in Melbourne's urban pattern. They too extend radially from the center of the city seeking easy gradients over the steadily rising interstream surfaces rather than following the tortuous and sometimes narrow lowlands along the streams or the arbitrarily drawn survey lines.

In consequence of the generous width of street allotments in nearly all portions of the city the rapidly increasing traffic flow of recent decades has presented a much less serious problem in Melbourne than in other large Australian cities. Even in the commercial core there is ample room along certain streets for parked automobiles in a middle zone as well as along the curbs. Serious congestion occurs only at important river crossings and in the vicinity of major passenger and freight terminals where large amounts of pedestrian and vehicular traffic are concentrated. Of course, serious congestion has always existed in the commercial core of Melbourne along the narrow lanes bisecting the ten-chain blocks. Along some of the major radial highways (former stock routes) a wide central strip is attractively landscaped and opposing lines of traffic are advantageously separated. In many suburbs, however, the excessively wide residential streets are prov-

ing to be a partial disadvantage because of heavy improvement and maintenance costs.

GENERAL URBAN FORM

The mass pattern of present-day occupance at Melbourne consists of a nonconcentric, semicircular form draped about the head of Port Phillip Bay (Fig. 8). From the central commercial core, situated about two miles north of the bay, the city has spread southward to the waterfront and to the west, north, and east for distances of six to fifteen miles or more. Extensive city development has spread farther to the north, east, and southeast than to the west or southwest. The lack of concentric growth may be explained largely in terms of the contrasting physical characteristics of the basalt plain on the west and the more diversified landforms developed on the sedimentary strata to the east.

The eastern shore of Port Phillip Bay is bordered by nearly continuous waterfront residential development for a distance of 25 miles to the south of Melbourne. Long stretches of sandy bathing beach, broken at intervals by rocky promontories, are backed by adequately drained residential lands 25–150 feet above sea level. Erosion has at times threatened the future of some of those beaches but elsewhere additional recreation land has been created by filling in shallow bay margins. Scattered resort development continues along the east shore to the very tip of the sandy peninsula which forms the east head at the entrance to the bay (Fig. 3, Inset Map).

The west side of Port Phillip Bay, in contrast, is nearly devoid of urban development. Low rocky shorelines and extensive tracts of poorly drained lowland discouraged urban development but the latter facilitated the establishment of an expansive sewage disposal farm at the mouth of the Werribee River some 18 miles southwest of the central city. The development of airports on certain alluvial flats along the west bay margin is under consideration. At Geelong where the shoreline is somewhat elevated and more attractive considerable urban growth has taken place, but it is separated from Melbourne by 30 miles of sparsely occupied grazing land.

Tongues of urban settlement extend beyond the general mass of the city along all the radiating railway routes thus illustrating the strong influence on city growth of the efficient electric interurban system which serves the Melbourne area (Fig. 8). Intervening peripheral areas not easily accessible to the rapid transit system remain essentially rural even though they are less distant from the central city than many suburbs along the railway.

Inadequately drained floodplain and delta lands near the mouths of the Yarra and Maribyrnong rivers comprise the largest tract of unused land occurring within the limits of the compact city area (Figs. 3 and 8). Most

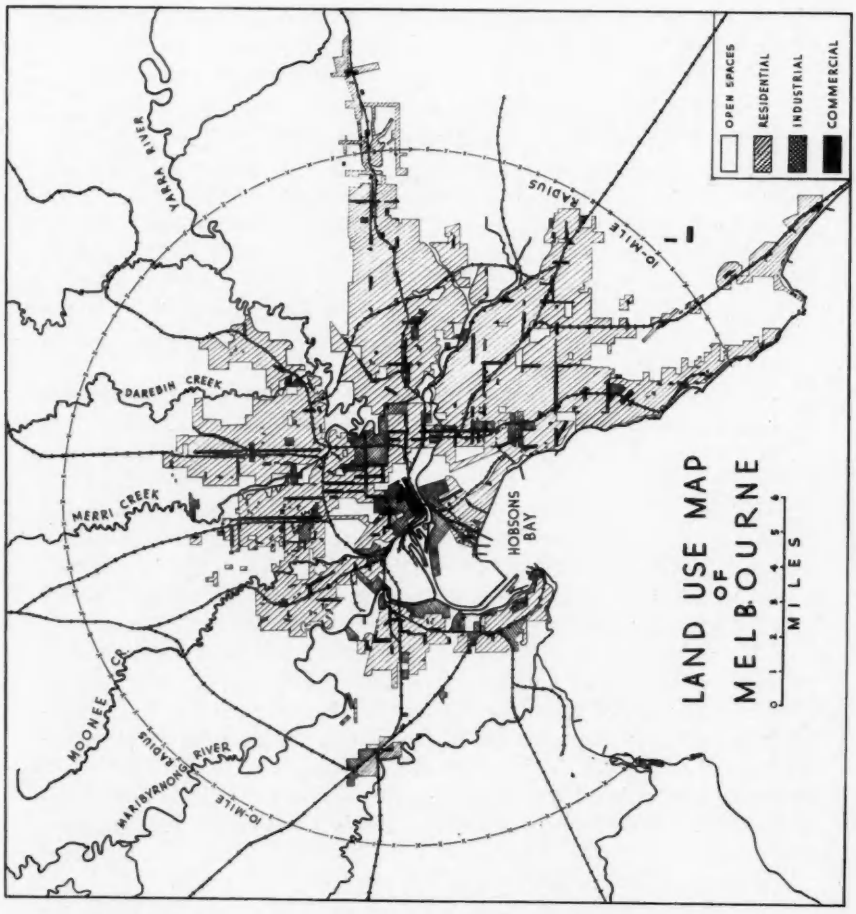


FIG. 8.—The extent of actual urban occupation in 1929 is shown as adapted from maps of the Metropolitan Town Planning Commission. Field examination has indicated that more recent growth of the city has caused some additional residential expansion, but the general usefulness of the map is not impaired. A 10-mile radius includes nearly all the developed urban area and much land which is in a pre-urban stage of development. Urban planning activities are generally restricted to the 10-mile radius while the jurisdiction of the water and sewerage board reaches out to the 13-mile radius and that of the suburban railway board extends outward 20 miles. The railways shown include both the metropolitan electric system and the steam lines serving the city; tram lines are not included.

of it probably will be devoted eventually to harbor development and to industrial purposes. Large tracts are publicly owned and may be filled in with harbor dredgings to create valuable waterfront lands. Difficulties of crossing the lower unbridged channels of the Yarra and Maribyrnong rivers and the associated marsh lands constitute another important factor in discouraging city expansion to the west and southwest.

The broad pattern of urban occupance is also strongly interrupted by the entrenched valleys of the streams which spread fan-wise over the Melbourne site (Fig. 8). Owing to flood hazards residential use of those lowlands is prohibited by law and as a consequence they are frequently devoted to pastoral or agricultural uses.[9] Flocks of hundreds of sheep may fre-

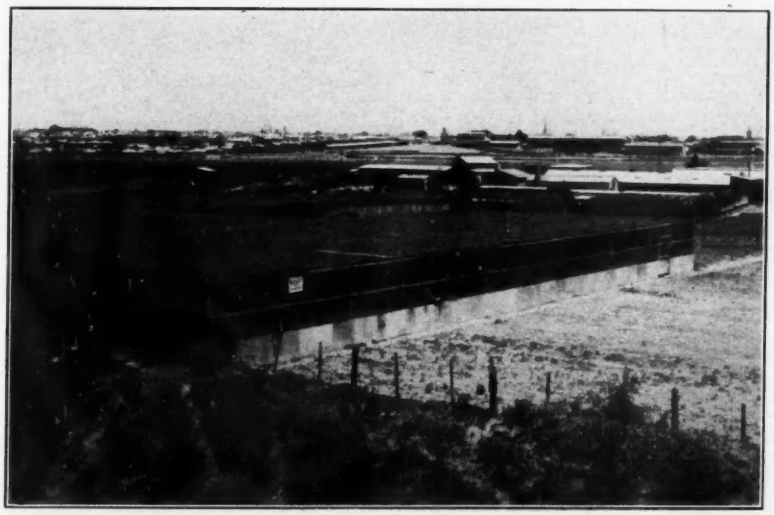


FIG. 9.—Intensive market gardening and floriculture are characteristic in portions of Moonee Creek Valley. A type of lath house constructed with native brush and numerous glass houses are shown in the midst of garden plots.

[9] The flood of December, 1934, attained the greatest heights of recent years along many streams in the vicinity of Melbourne. The local building ordinance now prohibits the construction of residences below the flood lines of that year. A few houses constructed on the lowlands before passage of the law are in the danger zone. In the early years of Melbourne, however, large losses occurred in connection with the major floods of 1863, 1878, 1891 and 1901. During the flood of April 15, 1878, hundreds of houses along the Yarra were inundated as reported in the *Illustrated Australian News* of that date. Although certain river improvements assist in reducing flood losses the city has come to recognize that it is not economically feasible to protect all lowlands against the exceptional floods.

FIG. 10.—A view across Moonee Creek Valley. The flat valley floor is occupied by the Moonee Valley race course while the bordering slopes and uplands are devoted to residences.

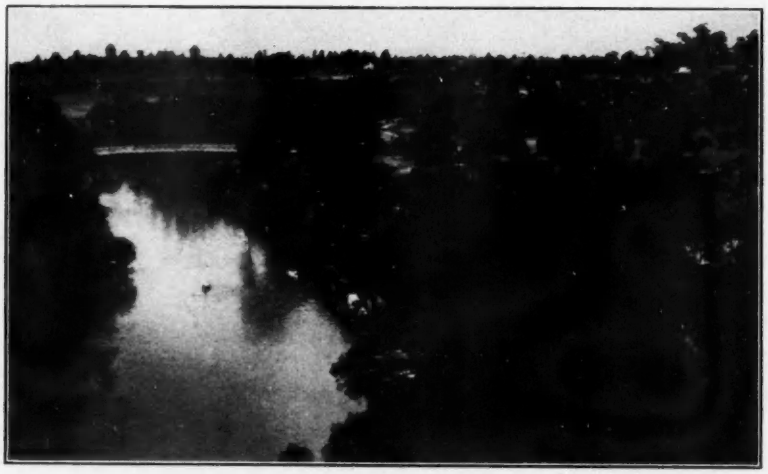


FIG. 11.—A scenic portion of the Yarra River in Kew, where it follows closely the margin of the basalt flow. The natural vegetation cover is preserved in many of the park areas.

quently be seen along the river lowlands within several miles of the central city. In places rich soils on terraces and floodplains encourage market gardening (Fig. 9). The larger expanses of flat land have attracted sports fields and racing courses to the valley bottoms (Fig. 10). The well-known Flemington racecourse, for example, lies on the floodplain of the lower Maribyrnong and the extensive grandstand is so constructed as to take advantage of the relatively steep margin of the bordering basalt upland.

Public parks have been created along the courses of the radial streams in many parts of the city (Fig. 11). Large native trees, running water, and picturesque valley margins provide attractive recreational features. Owing to early generous allotments of land for park purposes Melbourne has 2,500 acres of park land and public gardens within a three-mile radius of the central city (Fig. 12). Although such lands are well distributed cer-

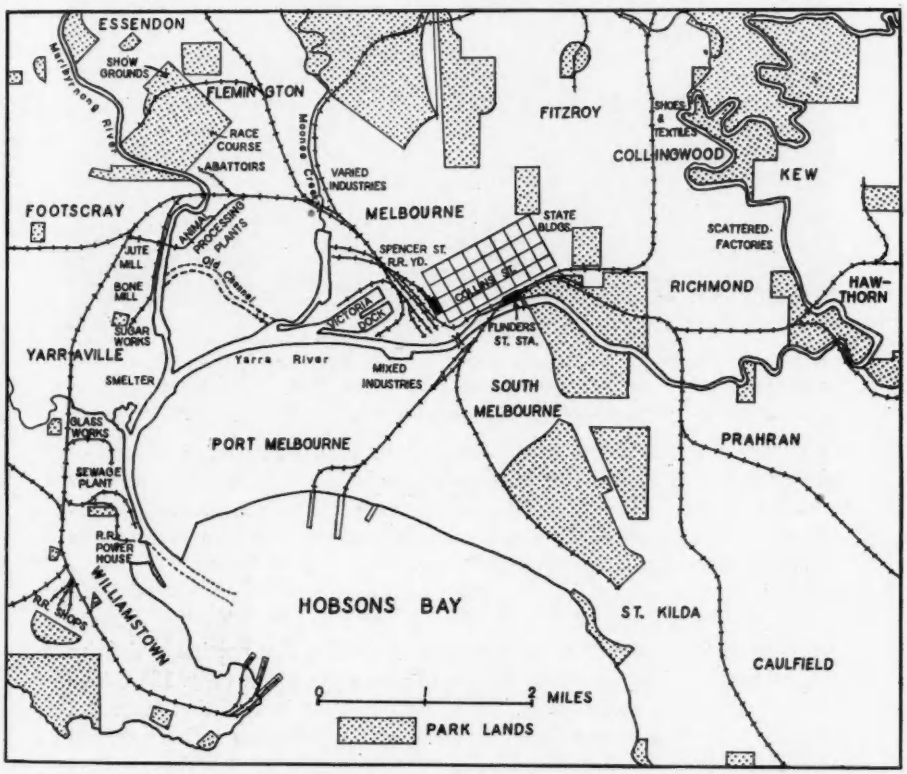


FIG. 12.—Map of the central portion of Melbourne showing names of municipalities, selected industries, park lands, and harbor development.

tain of the older crowded residential suburbs are deficient in recreation areas. In the newer suburbs with larger lots and private lawns and gardens less need for public parks is felt. However, the lowlands along the radiating streams provide excellent opportunities for the provision of additional recreation tracts in many parts of the metropolitan area.

Melbourne is a spacious city, spreading over a large territory because of the prevalence of single-family residences (Fig. 13). Within a ten-mile

FIG. 13.—Illustrating the manner in which the northeast suburbs of Melbourne are expanding upon the undulating upland surface. The inclosure of each property by a solid board fence is characteristic, and also reminiscent of days when wandering livestock needed to be excluded from suburban properties.

radius of the central city are included about 250 square miles of land of which only about a quarter is occupied to the extent of fifty per cent or more (Fig. 8). It has been estimated that three times the present population could be accommodated within an approximate ten-mile radius if all suitable lands were fully occupied.[10]

THE COMMERCIAL DISTRICT

The commercial core of Melbourne is situated in that portion of the city which was first laid out along the north bank of the Yarra (Fig. 12). The major retail shopping district lies in the northeast half of that tract and adjacent to the Flinders Street terminal of the suburban railway system

[10] Plan of General Development—Melbourne, *Report of the Metropolitan Town Planning Commission, 1929*, p. 23.

(Fig. 14). Street railways and bus lines focus upon the shopping district and attract retail business especially to the streets on which they operate. Theatres and a number of long-established churches are also distributed throughout that area. There is some evidence of the moving-in of important business establishments to the central city from the once-prosperous suburban retail centers in order to be at the focus of the new and efficient metropolitan transportation system. Adjacent to the shopping district on the northeast and flanked by extensive park lands are most of the state government buildings.

FIG. 14.—Aerial view to the north across the core area of Melbourne. The chief suburban railway terminal (Flinders Street Station) lies along the Yarra River in the left foreground. *Cf.* with Figure 12. (Courtesy of the Metropolitan Town Planning Commission.)

The principal terminal of the state railway system (Spencer Street Station) lies at the southwest end of the core area and it is an important factor in attracting business offices, hotels, railway administrative offices, port authority, customs house, and similar organizations to that vicinity (Fig. 12). On the northwest side the central shopping district is flanked by mixed wholesale, warehouse, and light industrial establishments along with scattered public buildings, as hospitals, public library, technical schools, law courts, public markets, and sundry state and city government buildings.

The central shopping district tends to expand southwesterly in the direction of the state railway terminal (Fig. 15) and along major thoroughfares toward the north where old residential development can be replaced with relative ease (Fig. 16). Many retail and wholesale establishments

FIG. 15.—View southwest along Collins Street in the central portion of the main shopping district. Swanston Street which crosses Collins at the low point one block ahead is another outstanding business thoroughfare. Several exceptionally tall buildings appear along this street. Few of the business streets are shaded by attractive plane trees as is this.

are located along the narrow streets or "lanes" which bisect the large blocks of the central area (Fig. 17). As business expands in the central core area many forms of industry and warehousing are forced to seek new locations in decadent residential districts while residents of the latter are likely to move to the newer outer suburbs. Expansion to the southeast across the Yarra River is of little consequence because large tracts of land adjacent to the principal bridge crossings have long been devoted to public parks and other tracts are undesirable because of low elevation (Fig. 12). In keeping with the widespread character of the entire city development most buildings even in the central city rise to heights of only three, four, or five stories. A maximum elevation of only 132 feet is permitted along the 99-foot streets.

Although the central shopping district is by far the most important, the widespread character of urban development in Melbourne has led to the establishment of subsidiary shopping districts throughout the metropolitan area (Fig. 8). The latter have developed as ribbons of commercial activity along the principal tram lines, becoming less and less continuous as the

FIG. 16.—Swanston Street is the principal cross-town commercial street. Many residents from the northern suburbs enter the commercial core along that line of approach. Note that most of the business structures are low.

outer suburbs are reached. Small shopping districts have likewise developed at most of the stations along the suburban railway system. Most of the outlying business streets reflect by their mixed and incomplete development the excessive and haphazard creation of business frontage. While the central shopping district caters to a wide variety of needs for the population of the entire metropolis, the neighborhood districts specialize in the commodities likely to be purchased from day-to-day by local families, such as foodstuffs, drugs, and small items of wearing apparel. Since there is no need for continuous ribbons of business establishments along all the major streets there is a growing tendency toward the creation of subsidiary business nodes at important outlying intersections.

INDUSTRIAL DISTRICTS

Melbourne has long held a position somewhat ahead of Sydney as a manufacturing center. The principal industrial district is situated near the head of Hobsons Bay where extensive tracts of low-lying and cheap land are available and where transportation facilities by land and sea are readily

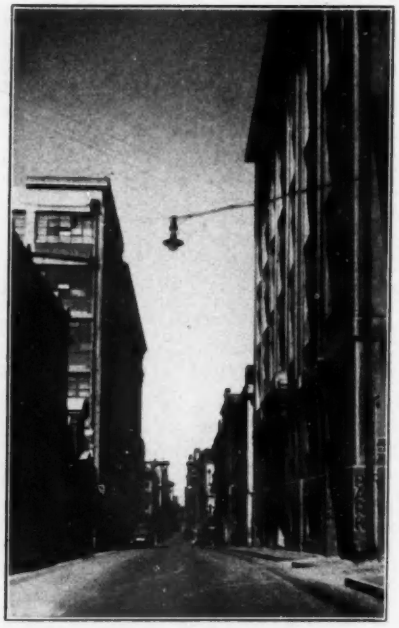


FIG. 17.—View along Little Collins Street which is representative of conditions along the one-way "lanes" in the core area. Lower costs of land in the centers of the large blocks have attracted many small retail shops to those streets along with wholesale, warehousing, and light manufacturing establishments.

secured (Fig. 8). Important scattered factory development has also taken place in the older and decadent residential suburbs which encircle the central city. Several new specialized industrial suburbs have arisen on the basalt plain to the west of Melbourne where land is especially cheap and where satisfactory railway service can be provided. The newer eastern foothill suburbs as well as those along the east shore of Port Phillip Bay are notably free from industrial development.

THE PORT INDUSTRIAL DISTRICT

As early as 1843, an area of about six square miles in the Yarra delta was reserved by public authority for the development of a future port and industrial district. Such a generous allocation of land should not be attributed to the foresight of the founders but rather to the unsuitability of the marshy lowlands for other purposes.

The extensive port industrial district has grown up in close association with the principal railway freight terminals and the shipping docks along the lower Yarra River (Fig. 8). Many industries cling to the inner margins of the delta lowland (adjacent to the higher ground), but as flood

protection is afforded increasing numbers of plants venture upon the lower tracts. Several square miles of the delta remain in their original condition and are utilized only for pasture.

The west margin of the lower Yarra and Maribyrnong rivers, extending through Williamstown, Yarraville, and Footscray, is almost entirely devoted to industry and shipping (Fig. 12). Piers extending from the basalt peninsula at Williamstown have long specialized in the shipment of bagged wheat, large quantities of which are stored in open sheds at the railway terminal. Idle warehouses and commercial buildings along the waterfront, however, point to the recent decline of general shipping at Williamstown. Several of the old piers are now being utilized as the center of operations for dredges and other equipment of the Melbourne Harbor Board. Facilities for general ship repairs are also available there.

At the entrance to the Yarra is situated the large Newport power plant of the Electric Railway Commission and a half mile inland are extensive car repair shops. Coal may be delivered by rail or by interstate collier for power development. Bulk storages for several major oil distributing companies are grouped along the Yarra margin since all petroleum products are imported from abroad. A large sugar refinery is supplied with raw material by boat from Queensland. Several large fertilizer plants receive raw phosphate rock from Nauru and Ocean islands and sulphur from Texas for the manufacture of super-phosphate. Gas works, the metropolitan sewage pumping plant, glass works, ore smelters, cement works, rubber manufacture, jute and woolen mills, corn products manufacture, wire weaving, and box and cooperage manufactures add to the variety of industries along the west bank of the lower Yarra.[11] Many of those plants draw water for industrial purposes from the river under license from the city. Special docks provide for the handling of materials for most of those industries.

Along the lower Maribyrnong River have developed numerous industries concerned with slaughtering and the processing of animal products (Figs. 8 and 12). The large municipal abattoirs and stock yards are situated on the delta lowland in Flemington. Large slaughtering and freezing plants of export firms occupy situations on the delta margins in Footscray (Fig. 18). Scores of related plants, both large and small, are scattered through the area, such as tallow rendering works, soap factories, bone grinding mills, tanneries, fellmongeries, wool stores, candle works, and pelt drying establishments. Taken together those industries create a major civic nuisance and residential development is discouraged on the west side

[11] Detailed facts about many of the principal industries of Melbourne are obtainable in Ambrose Pratt and Edward Leeson: *The National Handbook of Australia's Industries,* Melbourne, 1934, pp. 221–349.

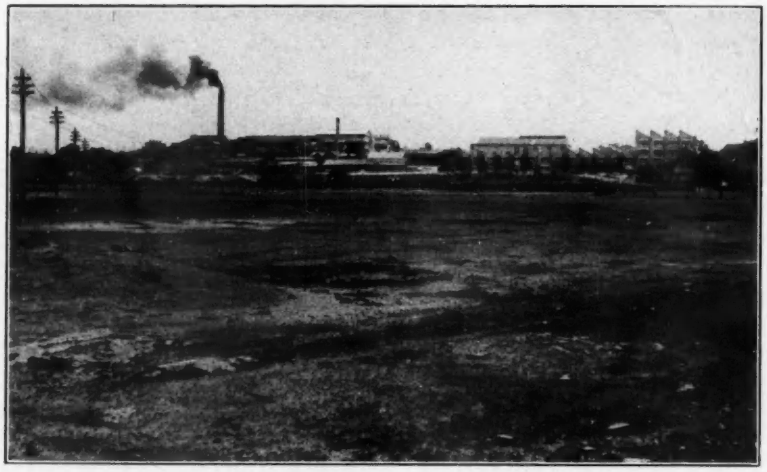


FIG. 18.—Large export slaughtering and freezing works on the delta margin in Footscray. The stock paddock in the foreground is located on the delta flats along the Maribyrnong River.

of Melbourne in part because of the odors arising in the intervening industrial district. Large investments in abattoirs and associated industries make any attempt to move them to a more suitable site an expensive undertaking. At the same time, the ever-present threat of being obliged to move discourages new investments in plant and equipment which would reduce the element of nuisance. Many basalt quarries and associated stone crushing and cutting plants are scattered through Footscray and adjoining municipalities in proximity to the railway lines.

Near the mouth of Moonee Creek, along the north delta margin and adjacent to the important Spencer Street Railway Yard and Victoria Dock, are more industries (Figs. 8 and 12). Government cool stores, municipal gas works, flour mills and grain storages, automobile works, biscuit factories, distilleries, timber mills, tanneries, wool, hide and skin stores, soap, rubber and chemical works, textile mills, wire works, foundries, and machinery shops are included. Warehouses for handling wool, sheep skins, cattle hides, rabbit pelts, tallow, and beeswax also occur in the nearby wholesale and storage district of the central city, representing in many instances the older establishments.

In the eastern portion of the delta lowland a large variety of newer industrial establishments has arisen along the Yarra River in South Mel-

bourne (Figs. 8 and 12). That district enjoys close access to all forms of transport and it is slowly expanding into decadent residential neighborhoods which early sprang up between the central city and Port Melbourne. Large motor vehicle and accessory plants, airplane factories, structural engineering and machine shops, textile mills, brewing and distilling plants, paper, soap, and chemical factories, and furniture and wood-working mills comprise the principal types. Numerous warehouses associated with the overseas and interstate docks give a commercial aspect to the district. Extensive coal and timber receiving docks and ship repair yards lie along the south side of the river near the head of navigation. Only a few industries and warehouses are located near the piers projecting into Hobsons Bay at Port Melbourne.

It is evident that the industrial groupings about the Yarra delta have arisen in response to the ready access of both water and railway transport and because of the large tracts of cheap lowlands available for factory sites. Accessibility to workmen's homes as well as to local centers of distribution are additional advantages for industrial development. Owing to the outstanding importance of the local metropolitan market nearly all industries find it advantageous to occupy situations convenient to the central city. Many of the harbor district industries also reflect clearly the fundamental character of Victoria's primary production for export as well as the resource deficiencies of the state which must be met by importation.

INNER SUBURBAN INDUSTRIAL DISTRICTS

Most of the older suburbs bordering the central city on the north and east have undergone considerable retrogression as residential districts (Fig. 8). There has been a strong centrifugal movement among residents toward newer communities as reflected by the stationary or declining populations of the close-in suburbs. However, many persons find it more economical to continue living in the somewhat obsolete houses and of marked advantage in securing employment in the many factories which have sprung up in those neighborhoods. Population densities continue to be higher in those decadent neighborhoods than in the newer suburbs because of crowding in multiple-unit structures. The most densely populated municipality in the Melbourne area is Fitzroy with 33.4 persons per acre in 1933, followed by Richmond with 27.7, and Collingwood with 26.5 persons per acre (Fig. 12).

These three municipalities possess a large variety of old and new manufacturing plants. Many of the newer establishments are widely scattered through decadent residential neighborhoods and only a few of them have railway connections. Some of the older establishments are located along

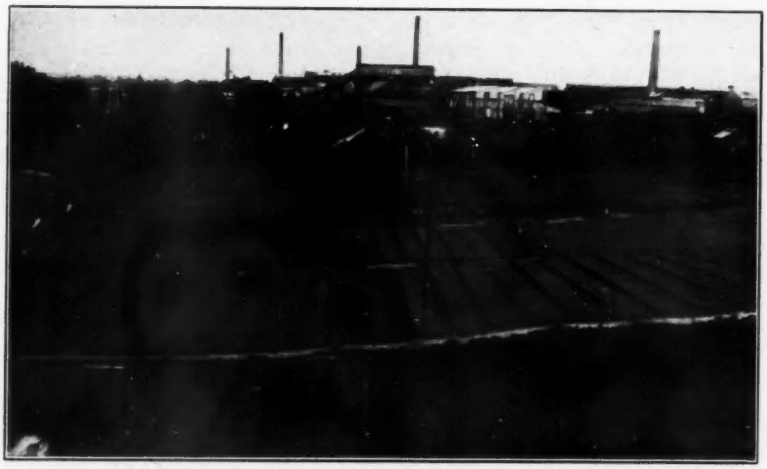


FIG. 19.—Chinese vegetable gardens along the willow-bordered Yarra in Richmond. Tanneries and wool-washing establishments are shown on the higher river margin.

FIG. 20.—A notable concentration of industries occurs along the Yarra River in Collingwood and is illustrative of the types which have developed in the older suburbs. Two large breweries, the principal Kodak manufacturing plant in Australia, a biscuit factory, a tannery, and others are included in this view.

the river which earlier provided a means of waste disposal as well as a source of water supply.

Characteristic of the older industries along the river in Richmond, and generally regarded as obnoxious because of their proximity to high grade residential districts across the river in Prahran, Kew, and Hawthorn, are an abattoir, a large municipal incinerating plant, a tallow and soap works, an abandoned clay pit now used as a city dump, numerous tanneries, a tar distillery, and several chemical works. Chinese vegetable gardens, pasture lands and public recreation areas commonly occur between clumps of industries located along the Yarra (Fig. 19).

Other industries scattered through decadent residential neighborhoods include important structural steel and metal working plants, machine shops, several breweries and malting establishments, electrical goods factories, furniture and wood working mills, wool scouring and weaving plants, flour mills and bakeries, confectionery and other food preparation factories, and a large photographic goods factory (Fig. 20).

A notable concentration of textile and shoe industries occurs along the Yarra River in Collingwood and adjacent Fitzroy (Fig. 21). Accessories

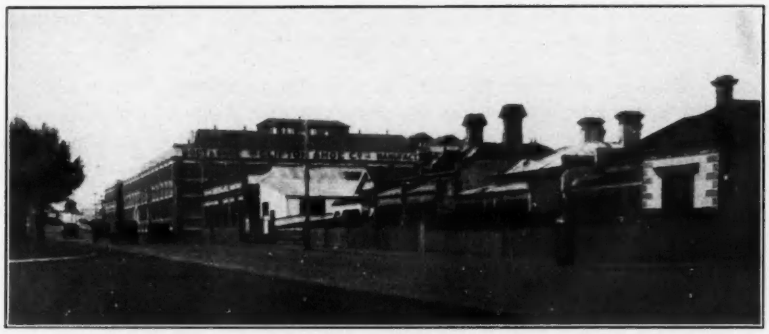


FIG. 21.—Boot and shoe factories in characteristic decadent residential neighborhood in Collingwood.

and supplies for the shoe industry are also manufactured there along with wool scouring and leather tanning machinery and equipment. Proximity to a large reservoir of skilled labor and easy access to the supply industries appear to be the only special advantages afforded by the Collingwood-Fitzroy district for the shoe industry. Few plants have direct railway contact and all depend for power upon the general municipal supply of electricity. Some encouragement is given the industry by the local municipalities but there are no free factory sites, reductions in power costs, or remissions of

FIG. 22.—This type of single-family residence is to be found throughout the newer eastern and northern suburbs. Painted weather-board walls, tile roofs, low wire fences and privet hedges, ornamental date palms in the parking strip, and crushed bluestone on the street surface comprise the residential street assembly.

taxes. Factory sites of sufficient size for the shoe industry are readily available in those suburbs which are undergoing gradual decadence from a residential viewpoint. Since most factories deliver their product directly to retail and wholesale establishments in Melbourne the advantage of close proximity to the commercial core is readily appreciated. The principal market for shoes made in Melbourne is the metropolitan area itself along with its tributary rural districts.

Boot and shoe manufacturing is one of the principal secondary industries in Australia, three-fifths of which is concentrated in Victoria and chiefly in the Melbourne area. About 10,000 persons in Victoria are employed in the industry, which derives most of its raw materials from local sources.

Textile mills of many descriptions and sizes also occur in the Richmond-Collingwood district. Wool, cotton, silk, and other materials are spun, woven, knit, and dyed to meet the diversified needs of Melbourne and its tributary areas. Clothing factories convert much of the yardage produced locally into finished garments.

Important industrial development has also taken place in certain outlying suburbs. Numerous spinning, knitting, and weaving mills form a significant industrial grouping along the railway in Coburg, five miles north

of the central city. Brick, tile, and pottery manufacture from local clays give character to the industry of several northern suburbs (Fig. 3). Similar plants occur along the railways extending southeast and east from Melbourne, commonly at the margin of city development where lands are cheap or along stream courses where clay beds are readily opened. Since brick is by far the most important building material used in Melbourne great significance may be attached to the brick and tile yard development in various parts of the city (Fig. 22).

A major reason for the widespread distribution of various types of industries through many of Melbourne's inner suburbs has been the absence of zoning restrictions in the past. There is need to prevent any further excessive spread of industry with its accompanying damage to other urban forms in the conveniently situated close-in suburbs. There will always be large numbers of persons who will find it advantageous to reside within short distances of the commercial core. Furthermore it should not be necessary for residents of the outer suburbs to pass through wide zones of blight each time they enter or leave the central city.

Small industrial groupings in the southeastern suburbs do not seriously detract from the essentially residential character of this area. The advantages of bringing employment as near as possible to the homes of workers is illustrated in numerous neighborhoods. By careful regulation and localization such industries assist greatly in the creation of semi-independent, well-rounded local communities. Further development along that line might prove highly advantageous if Melbourne is to expand further in population and area.

Outstanding among the industrial developments on the periphery of Melbourne and illustrative of the concept of decentralization is that at Sunshine, eight miles west of the central city on the open basalt plain (Fig. 8). The establishment of an important agricultural implement works at the railway junction led to the creation of the town which later succeeded in attracting a few other industries as well. Large scale explosives manufacture is carried on at a point three miles west of Sunshine and chosen for its detached position. It is likely that heavy or obnoxious industries may migrate in the future toward Sunshine where railway transport is especially convenient and where unlimited tracts of cheap land can be obtained. It is proposed by some that all slaughtering establishments, livestock sales yards, and related establishments be moved to that margin of the metropolitan area. Requisite connections with the metropolitan water, sewage, and power systems could be easily provided.

POWER AND WATER SUPPLIES

The development of industry and the modernization of living in Mel-

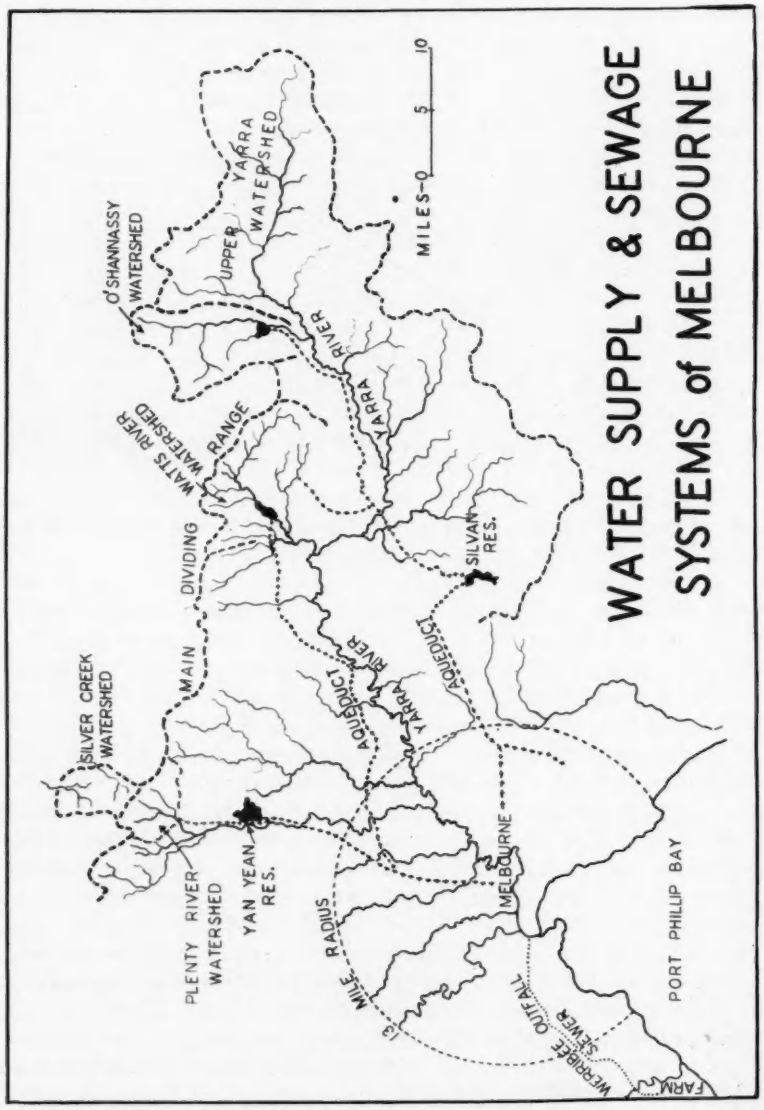


FIG. 23.—Map of the water supply and sewerage systems of Melbourne. Yan Yean and Silvan reservoirs are primarily distributing reservoirs. The aqueducts consist of masonry-lined ditches and steel conduits. The service area coming under the jurisdiction of the water and sewerage board includes 434 square miles or all land within a 13-mile radius of the central post office.

bourne has been greatly facilitated since 1924 by the operation of the large state-owned electricity scheme at Yallourn (Fig. 1). Except for the metropolitan electric railways, which are supplied by the power plant on the lower Yarra, most of the electricity consumed at Melbourne and in other towns and cities of Victoria is obtained from the single large installation 100 miles east of Melbourne. More than 200 rural towns are served by the system of transmission lines reaching out over a radius of nearly 300 miles from Melbourne as the principal load center. Generating capacity at Yallourn amounts to about 150,000 K.W.[12]

The source of power at Yallourn is lignite extracted from an opencut by modern mechanical devices. The annual output of lignite is about 2½ million tons and the total reserve within six miles of the power plant is estimated at six billion tons.[13] A deposit of lignite 200 feet in thickness occurs beneath 30 feet of overburden at the existing operation. Nearly half the present output of lignite is sent to a briquetting plant at Yallourn for preparation as industrial and domestic fuel for shipment to Melbourne and other centers. Raw lignite is utilized in the electric power plant. Although large quantities of Newcastle coal are brought by sea to Melbourne for gas manufacture it is not unlikely that at some time gas may be produced from lignite at Yallourn and sent by pipe line to Melbourne.

The steady expansion of the Yallourn electrical undertaking has made possible the closing of many small inefficient electric plants throughout the state in addition to bringing that form of power to many small centers previously unsupplied. The employment of about a thousand workers at Yallourn has led to the establishment of a town of 2,300 persons at the power center.

Early Melbourne obtained its water supply from the lower Yarra River adjacent to the initial point of settlement. By 1850 the inadequacy of that arrangement was recognized and the city began construction of a dam at Yan Yean across the Plenty River, a northern tributary of the Yarra (Fig. 23). The new source of supply, with a twenty-mile connecting pipe line was completed in 1857. During the 1880's several other watersheds were added to that system, including the headwaters of the Goulburn River (Silver Creek Watershed) across the Great Dividing Range. All later additions to the Melbourne water supply are included in the drainage area of the Yarra River system.

In 1891, large addition to the Melbourne water supply was made by the initial development of the Maroondah watershed on the Watts River, 75 miles to the northeast of the city. In 1914 the more distant O'Shannassy watershed was tapped. While the original Yan Yean watershed included

[12] Gawler, O.: *Victorian Yearbook, 1934–5*, p. 486.

[13] *Report of the Royal Commission on the Coal Industry*, Legislative Assembly, N. S. W., 1929–30, p. 33.

5,700 acres much greater areas are involved in later supplies—Plenty River 10,500 acres; Goulburn River 11,500; Watts River 40,000; and O'Shannassy River 32,650. An additional watershed covering 90,000 acres has been reserved for future metropolitan use on the easternmost headwaters of the Yarra River.

All of the Melbourne watersheds are situated in heavily timbered, uninhabited, and mountainous country with elevations as high as 3,000–4,000 feet. An average rainfall of 30–60 inches is recorded on the several watersheds.[14] Owing to the very absorbent character of the volcanic materials covering much of the watershed, the rate of run-off is notably uniform. Smaller storage capacity is required as a consequence, although existing reservoirs hold enough water to supply the city for a year. Yan Yean and Sylvan reservoirs are essentially distributing reservoirs in the gravity system of aqueducts.

The entire area within a 13-mile radius of the central city (434 square miles) is supplied by water from the metropolitan system. The approximate daily water consumption per capita amounts to 60 gallons. Filtration and chemical treatment of the water are not required, thus reflecting the high quality of the supply.

Prior to 1897 the city of Melbourne was without a suitable sewerage system. Much waste material was dumped into the Yarra River which caused that stream to acquire a most unenviable reputation. By 1920 essentially all the city was cared for by the existing sewerage system. The whole of the metropolitan sewage (42 gallons daily per capita) is delivered by a 16-mile aqueduct along the west side of Port Phillip Bay to the Werribee sewage farm (Fig. 23).

The metropolitan sewage farm consists of a tract of land of 23,000 acres situated at the mouth of the Werribee River and fronting on the bay for a distance of 14 miles. The developed portion of 10,000 acres is divided into 20-acre tracts for sewage irrigation. The general procedure is to apply three inches of screened sewage water to 500 acres each day and at the end of 16 or 18 days to repeat the process. Forage crops are grown on those lands and large numbers of sheep are pastured, thus providing some revenue from the undertaking. Following the treatment by land filtration the effluent is eventually discharged into the margins of the bay.

HARBOR DEVELOPMENT

The development of Melbourne as a port is interesting geographically because of the numerous difficulties which have been overcome, because of

[14] Melbourne and Metropolitan Board of Works, *Report for the year ending June 30, 1935*, p. 4.

the rivalry among towns for the early trade of the Port Phillip district, and because of the distribution of present-day trade among the several parts of the bay district.

Port Phillip Bay is about 30 miles long from north to south and more than 20 miles wide, with Corio Bay forming a narrower western arm penetrating more than 15 miles beyond the general limits of the embayment (Fig. 3, Inset Map). The entrance to Port Phillip Bay is nearly two miles wide but the reef projecting from the heads reduces the navigable channel to less than a half mile. Large portions of the bay have depths of less than five fathoms and as a consequence ship movements are generally limited to certain well-defined channels where suitable depths are maintained by dredging.

The site selected for Melbourne in 1837, nine miles up the Yarra River, proved during the gold rush years to have serious drawbacks for the conduct of an extensive commerce. Only nine feet of water was available at full tide and the river was so circuitous that "from no direction would any one wind send a vessel up to the town."[15] Much freight was lightered from vessels anchored in Hobsons Bay and at times "the freight costs for the last nine miles of the voyage from Britain to Melbourne were equal to the costs for the first 14,000 miles."

Although larger vessels were unable to approach within several miles of the wharves at Geelong because of a bar in Corio Bay yet that town experienced rapid development because of access to the western pastoral district and the Ballarat gold field (Fig. 1).[16] In 1856, Geelong, with a population of about 20,000, was the third largest city in Australia. Williamstown, with its protected harbor accessible from the open bay, was another important center of shipping during the gold rush and its waterfront was usually lined with sailing vessels.

In order to overcome the handicap of the lower Yarra and to give Melbourne better access to Port Phillip Bay the first railway in the state was built from the city two miles south to Port Melbourne in 1854 (Fig. 12). Another short line was built to the Williamstown wharves. Owing to the ease of constructing a railway over the level basalt plain the Williamstown railway was extended to Geelong by 1857. Melbourne thus early acquired railway connections with the three important shipping points on Port Phillip Bay.

Although Geelong succeeded in getting direct railway connections with Ballarat and with the western district during the 1860s, adequate harbor

[15] Westgarth, William: *Victoria, cit.*, p. 61.

[16] Mackenzie, A. C.: *Proceedings of Town Planning Meeting, Adelaide*, 1917, p. 101.

dredging operations were not undertaken until the 1880s, by which time its trade was far outstripped by that of Melbourne. The decision in 1851 to make Melbourne the capital of the newly-created state of Victoria removed the likelihood of Geelong's ever becoming the major city. The governmental policy of focusing the bulk of the trade upon the capital city and of attempting to overcome any of its site handicaps was largely responsible for Geelong's dropping out of the competition. Williamstown was quickly absorbed by the expanding Melbourne.

In 1860 vessels drawing 10 or 11 feet of water were able to navigate the Yarra and it is said that captains were accustomed to clear their vessels of marine growths by scraping the muddy bottom of the river.[17] By successive dredging operations the river was widened and deepened until at present a channel having a width of about 400 feet and a depth of 29 feet is available. A major project for straightening and shortening the channel was completed in 1886 by means of the Coode Canal across Fishermen's Bend,[18] (Fig. 12). Miles of piling and loose rock walls have been built to constrict the channel and thus increase river scour. Navigation channels across Port Phillip Bay have had to be deepened from time to time to keep abreast of the increase in size of overseas ships. Depths of 37 feet are available for ships at Port Melbourne and 34 feet at Williamstown. Although Port Phillip Bay appears at first glance to be a commodious and ample natural harbor, closer inspection shows that extensive improvements were required to meet the demands of modern shipping.

MELBOURNE'S TRADE

An examination of the types of commodities handled and the tonnages involved in Melbourne's trade reflects not only the character of urban industry but also the nature of economic activity and resources throughout its hinterland. Interstate and coastal trade was slightly more important than overseas trade at Melbourne in 1935, in which year the combined volume was $5\frac{1}{4}$ million tons. Import tonnages were about twice as important as export tonnages in both classes of trade due largely to the bulky character of raw materials and fuels being received. One-third of the overseas imports consisted of petroleum products; timber, paper, phosphate rock, and automobile parts were other major items of tonnage. Coal comprised nearly half the domestic imports; and, iron and steel products, raw

[17] McCutchan, J. H.: *The Melbourne Harbour Trust; The Official Centenary Guide and Souvenir*, Melbourne, 1934–5, p. 59.

[18] *Official Handbook of the Port of Melbourne*, Melbourne Harbor Trust Commissioners, 1933, pp. 22–23.

sugar, gypsum, pyrites, and grain were other important commodities received.[19]

Among the overseas exports wheat and wheat flour accounted for two-fifths of the tonnage; and, frozen lamb and mutton, wool, and fruits were of major importance. In the domestic export trade motor cars, machinery, textile manufactures, boots and shoes, and rubber products were significant items. Thus it is clearly seen that Melbourne is an important producer of manufactured goods which it exchanges for raw materials in other parts of Australia. It is also evident that Melbourne is still engaged in shipping raw materials and partially fabricated products of the farm and range to foreign countries in exchange for manufactures and essential fuels and raw materials unavailable in Australia (Fig. 24).

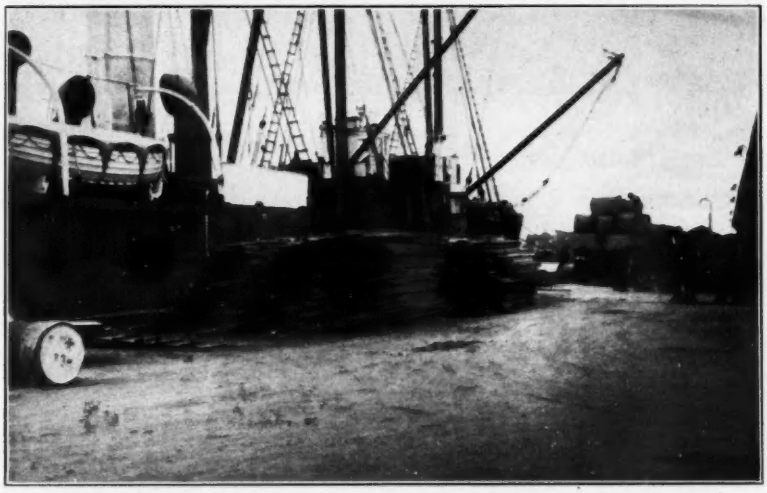


FIG. 24.—Characteristic coastwise steamer at Victoria Dock. Bales of wool and eucalyptus lumber have been discharged. Heavy draft horses are employed on the docks for moving cargo.

Another interesting aspect of the ocean trade at Melbourne is the concentration of certain portions of that business in different parts of the port largely as a consequence of water depths available to shipping and convenience with respect to warehouses, railway terminals, and factories. Of particular importance is the fact that 96% of all import and 75% of all export tonnages are handled over wharves situated along the Yarra River (Fig. 25). In 1878, only 58% of the import tonnage and 62% of the export ton-

[19] *59th Annual Report of the Melbourne Harbor Trust Commissioners*, 1935.

FIG. 25.—View across one of the large shipping basins dredged out of the marsh along the lower Yarra River channel with the central city in the background.

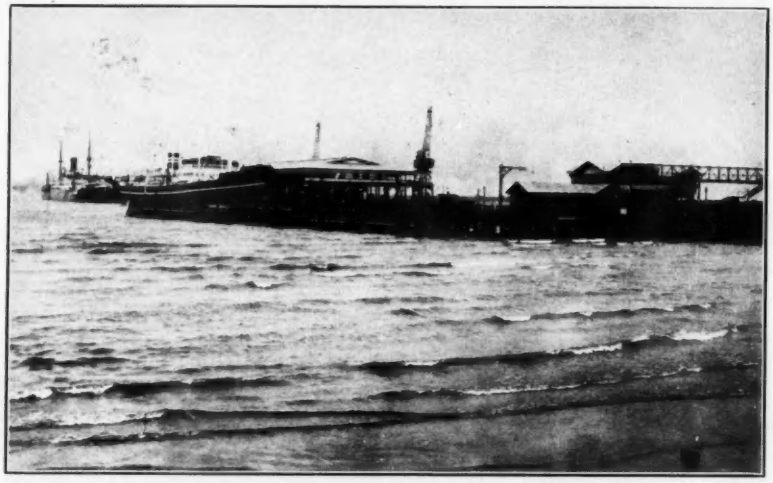


FIG. 26.—A view of the Port Melbourne piers projecting into Hobsons Bay over which passengers and cargo are handled for the larger overseas ships.

nage was handled in the river but the proportions have increased regularly with river dredging operations. The import trade in lumber and coal is concentrated at special wharves along the south bank of the river near the

central city while the heavy import trade in petroleum products, phosphate rock, and pyrites is localized along the west bank of the lower Yarra in Williamstown and Footscray (Fig. 12). Large quantities of flour, meats, and wool bound for overseas markets are loaded at the river wharves in close proximity to the warehouses, abattoirs, and mills in the Yarra delta. Likewise, most of the manufactured goods sent to interstate markets are loaded at the river docks in close proximity to manufacturing establishments.

The principal function of the Port Melbourne piers is in the handling of the overseas passenger and package freight traffic as well as to export considerable wool which moves abroad on large passenger liners (Fig. 26). The recent construction of a large government-owned bulk wheat terminal at Geelong is significant not only because it indicates an important change in the mode of handling wheat but because it foreshadows a shift of the principal export wheat trade from Williamstown to Geelong.

CONCLUSION

The relatively late foundation of Melbourne as a British settlement may be attributed to the prior emphasis placed upon the east coast penal establishments. First directed toward a pastoral existence, Melbourne had thrust upon it far wider responsibilities by the inrush of the gold-seeking hordes. The collapse of that boom turned many of the new arrivals to more dependable occupations. Agriculture gradually encroached upon the extensive sheep paddocks and commerce and industry drew many miners back to the rapidly expanding Melbourne. A strong local policy of protection encouraged the growth of manufacturing, and access to rich agricultural and pastoral lands promoted commerce.

Even Sydney was surpassed by Melbourne's phenomenal growth, a position of priority it held until after the Commonwealth was established in 1901. Strong rivalries, begun in the years of competitive statehood, continue to make themselves evident on numerous occasions. Although Melbourne served for 26 years as the temporary capital of the Commonwealth, the firm resolve by Sydney, that it or another center in New South Wales must be chosen, finally led to the compromise establishment of Canberra as the permanent seat of Federal Government.

Melbourne will gain in importance in the future as population, industry, and commerce throughout Australia expand. Its manufactured goods will continue to move to those states unable to duplicate the larger modern factories because of their limited markets or resources. As the artificial ties, which have in the past restricted the normal movement of goods across state lines, are broken, Melbourne is likely to claim an increasing share of the trade of the rich "Riverina" district across the State boundary in New

South Wales. Some railways have already been extended across the Murray River into that interior district and others are likely to be built. The occasional vociferous claims of Riverina residents for a more economical outlet to the sea than through Sydney may find the answer to be "through Melbourne."

Although Victoria displays by far the highest population density of any of the states (21 per square mile) much opportunity remains for closer settlement. Large portions of the moist Gippsland District, for example, are now occupied by a scattered population engaged in extensive farming and pastoral pursuits. Most are agreed that future settlement in Australia will take place in the same general areas now supporting the bulk of the population. With the additional advantage of the best climate for human energy enjoyed in any of the major cities of the continent, Melbourne in all probability will acquire its full quota of new urban growth.

In keeping with its British inheritance Melbourne is characterized by a mien of formality and reserve not only in its architectural types but also in the daily life of its citizens. Attention to business has large attraction for a conservative population, but not to the exclusion of horse-racing and other out-door activities. Even Melbourne's parks, with their English trees and velvety lawns, reflect a quiet dignity and an atmosphere of well-being characteristic of the state itself. As a government official expressed it—"Even if we had the wealth of New South Wales we should not spend it on such *frivolities* as harbour bridges and voluminous government publications."

University of California, Los Angeles.
January, 1941.

The Glaciated Sand Region of Central Wisconsin

LOYAL DURAND, JR.

REGIONAL REPUTATIONS

Cities, localities, and regions frequently obtain reputations for their products—reputations which become valuable advertising assets beyond the home community, and reputations which may in turn attract other manufacturers or dispensers of the noted product to the city, locality, or region. States, likewise, attain characteristic industries and attitudes, and a "feeling" may come to pervade the inhabitants of the area—a pride in the enterprise. The "state characteristic," difficult to measure objectively, sweeps from border to border, oftentimes stamping the landscape with undoubted elements of importance, and carrying the industry or enterprise into regions not always the most ideally suited to it.

Rural Wisconsin is organized around the dairy industry. The whole state is conscious of this farm enterprise. *America's Dairyland* was stamped on all 1940 and 1941 license plates of motor vehicles. The travelling motorists thus aid in spreading the fame of their home state's dairy products across the nation, and into Canada and Mexico, even though they are among the 53.5% (1940 census) of Wisconsin's inhabitants who live in communities of 2500 and upwards. So conscious is Wisconsin of dairying, that it is usually taken for granted that that occupation supports the farmer. Farms are valued and salable, not alone for their land, but for their buildings, and the value of the latter constitute a rather respectable proportion of the total farm valuation of the state—about 43% at the time of the 1930 census. Dairying has spread across Wisconsin from border to border—from the Illinois line to Lake Superior, and from Lake Michigan to the Mississippi —until to a high degree the rural portions of the state are literally "one industry" regions. Gross farm income in Wisconsin for the decade 1927–1936 was accounted for by the following constituents: sale of milk 50.2%, sale of cattle and calves 11.3%, chickens and eggs 9.8%, swine 11.5%, sale of crops 16.3%, and all other sources .9%.[1] The United States as a whole for the same period saw milk accounting for but 20.34% of the nation's

[1] Wisconsin and United States Department of Agriculture, *Crop Reporting Service Bulletin No. 200, 1939*—Wisconsin Dairying, pp. 1, 2.

gross farm income, while sale of crops accounted nationally for 41.2%.[2] With over two-thirds of Wisconsin's farm income directly dependent upon the sale of milk, and closely associated products such as cattle, calves, chickens, and eggs, it is evident that fluctuations in milk prices, varying consumption of fluid milk, butter, and cheese, and other market factors will exert a strong effect upon the prosperity of the state—directly on the rural portion, indirectly on portions of the urban population, especially outside of the intensive manufactural sections along the shore of Lake Michigan.

AN ENVIRONMENTAL PARADOX

Geographers commonly associate dairying with a specific environment, at least so far as the northern portions of the United States are concerned. In Wisconsin, with its statewide rural feeling, dairying also dominates different environments than the usual, and is a leading agricultural enterprise even in the sandy portions of the state. The purpose of this paper is to resolve the apparent paradox. The study will trace the expansion of the dairy industry from the glaciated lands of the southeastern section of the state, its nucleus in Wisconsin, into the Central Glaciated Sand Region. It will deal with the advent of dairying in the region of generally low quality sandy soils, and the eventual modification of the landscape of that sand country by the addition of cultural elements such as large dairy barns, creameries, cheese factories, and the dairy herds themselves. Perhaps in many situations other than Wisconsin, the Glaciated Sand might not have developed into a dairy region; in Wisconsin it was almost impossible to resist.

THE CENTRAL GLACIATED SAND REGION—NATURAL FEATURES

The Glaciated Sand Region of Central Wisconsin is a gently rolling area of approximately 4000 square miles in the east-central portion of the state[3] (Fig. 1). Except on the west, beyond the terminal moraine of the Wisconsin glacier, the region meets areas of good to excellent agricultural quality along its transitional borders. To the south and east it abuts against the highly developed countryside of southeastern Wisconsin along a border that is sharply marked over considerable distances by a soil change, and elsewhere is marked by a five to ten mile wide transition between the clay and loam soils on the one hand and sandy loams and sands on the other. On the north and northeastern margin, the heavier soils of the agricultural

[2] *Ibid.*, p. 2.

[3] A map of the geographic regions of Wisconsin is found in the *Geographical Review*, Vol. 23, 1933, p. 135. A study dealing with the effects of glaciation in the sandy region is that by R. H. Whitbeck, "Economic Aspects of the Glaciation of Wisconsin," *Annals of the Association of American Geographers*, Vol. 3, 1913, pp. 62–87.

Middle North of Wisconsin appear. The entire northern border of the region is transitional in character, but discernible in the landscape by many cultural items associated with more intensive land use, and by natural items

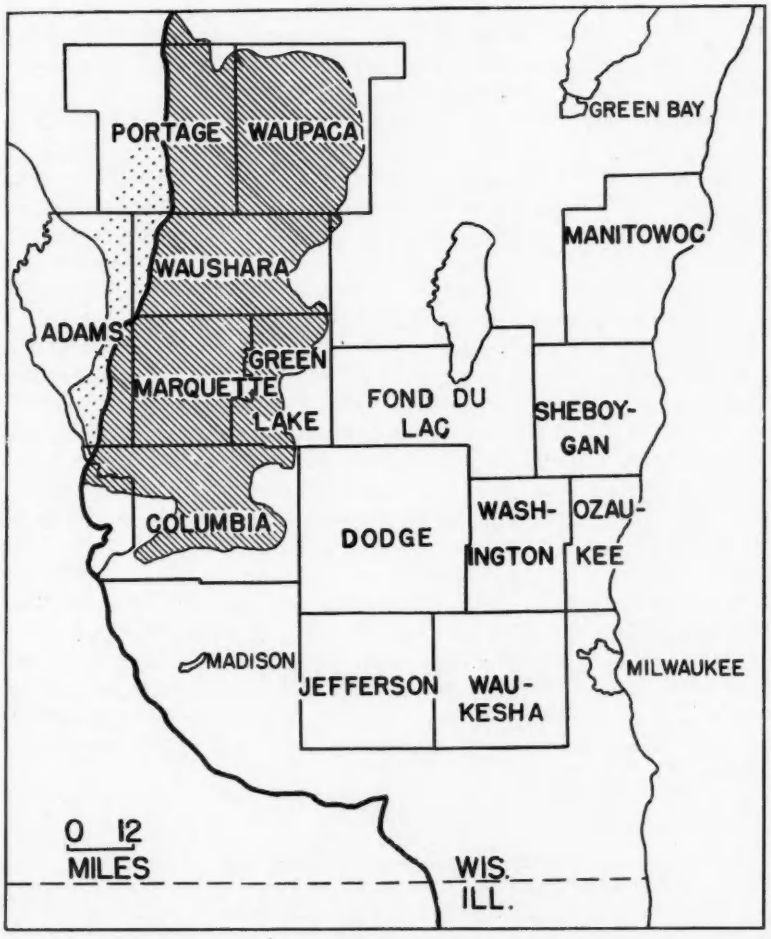


FIG. 1.—Locational map. The Glaciated Sand Region of Central Wisconsin is shaded. The dotted areas are regions wherein glacial outwash of Wisconsin age is prominent. West of Portage County this grades into old drift. The terminal moraine of Wisconsin glacial age is marked by the heavy line.

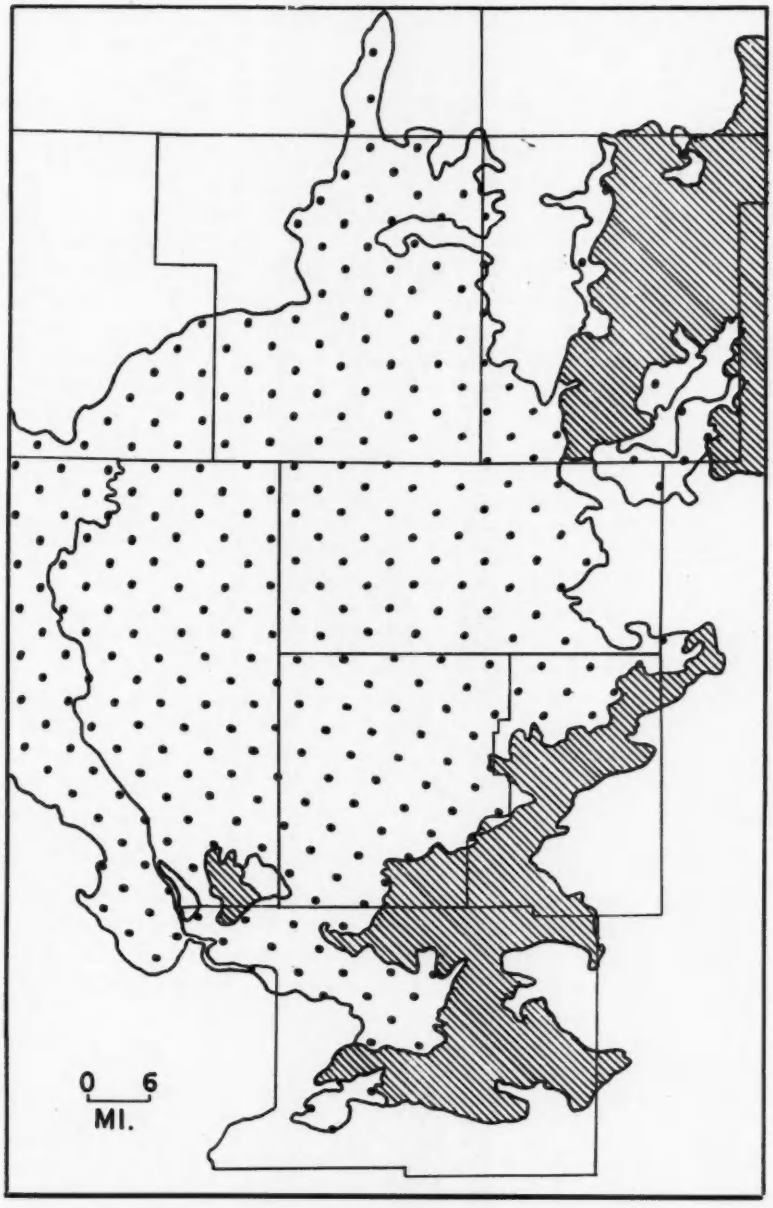
that bespeak an environment tending toward that of the northern Wisconsin type. On the west the Glaciated Sand is limited by the terminal moraine of the Wisconsin glacier. Beyond the moraine in the unglaciated district lies the generally infertile, essentially non-agricultural Central Sand Plain of the state, the "hole" in the dairy belt.[4]

The Central Glaciated Sand Region possesses a land surface not unlike other portions of the glaciated sections of Wisconsin, and an identical climate—the Humid Continental Short Summer type (**Dfb**). Relative relief of from 150 to 300 feet characterizes the land surface throughout. The configuration is undulating to strongly rolling. Drumlins, till plains, outwash plains, old lake beds, and drift-mantled rock-controlled sections dominate the area. Glacial drift is commonly sandy in nature, the result of ice movement over the underlying series of sandstones of Cambrian age. Advance of the ice sheet from the northeast, however, resulted in considerable admixture of clay drift derived from the limestone areas of eastern Wisconsin, as well as the admixture of some sand and clay materials from the granitic areas of the Laurentian Upland, the latter especially in the northern portion of the region. Soil types are either sands or sandy loams on the drift-mantled uplands and outwash plains (Fig. 2). Peat or muck is found in the numerous glacial marshes and swamps. Hardwood trees, principally the oak, dominate the woodland scene; originally the area was partly forest land, and partly "oak opening," wherein many grassy swales were interspersed amongst a thin stand of oaks. Pine makes its appearance in the extreme northern portion of the area, in the vicinity of Waupaca, but is not a dominant tree except locally.

The Central Glaciated Sand Region is poor relatively within the Wisconsin state setting. In certain respects it is poor absolutely. However, its location in a general area of highly developed agricultural lands to its east and south places the region at a relative disadvantage in Wisconsin, when by comparison with other sandy soil areas in the United States it is of fair quality. Compared too with other sandy soil areas, its landscape, with

[4] Richard Hartshorne, "A New Map of the Dairy Areas of the United States," *Economic Geography*, Vol. 11, 1935, pp. 347–355. Reference to the "hole" in the dairy area is made on page 349. Reference to the sandy portions of central Wisconsin are also made in O. E. Baker, "Agricultural Regions of North America, Part V—The Hay and Dairying Belt," *Economic Geography*, Vol. 4, 1928, pp. 44–73.

FIG. 2.—Sandy and sandy loam soils of Central Wisconsin (after general soils map accompanying *Bulletin 68, Wisconsin Geological and Natural History Survey*, 1927). Sandy soils are stippled; sandy loam soils are barred. Note the location of the sandy loam soils on the eastern margins of the Sand Region. The Green Bay Lobe of the Wisconsin glacier advanced from the northeast and east in this section of the state.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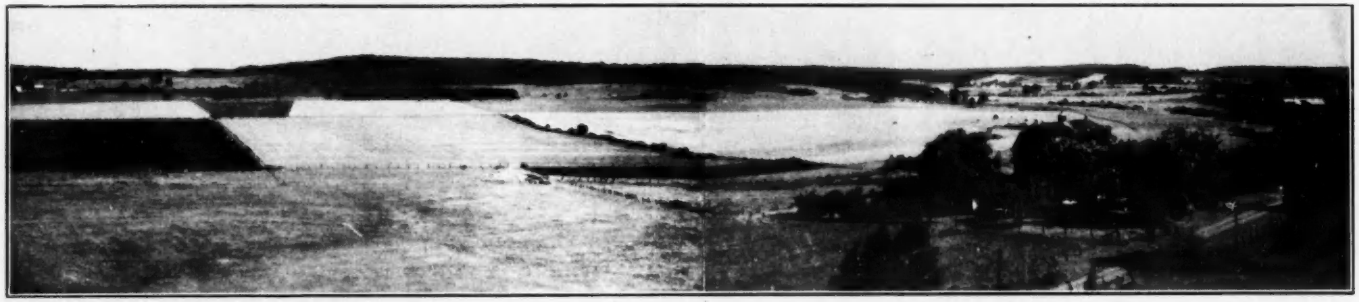

FIG. 3.—The Central Glaciated Sand Region in western Waupaca County. Merging of the distant wooded drumlins produces a wooded skyline. The light colored fields are in oats and rye. Note the dairy barn in the foreground. (Wisconsin Geological Survey Photograph.)

dairy barns, silos, milk houses, and similar visible accoutrements of the dairy industry produces a favorable impression upon the traveler (Fig. 3).

SETTLEMENT OF THE CENTRAL GLACIATED SAND REGION

Agricultural occupance of the Central Glaciated Sand Region began in the 1840s, and by 1850 much of the southern and southeastern portion was settled. By 1860 the rural population density in the southern two-thirds of the region was not far different from the present figure.[5] The northern part received its influx of immigrants in the 1860s and 70s, and has been able, since then, to increase its rural population, and especially its villages and cities, so that it supports now more inhabitants than the older settled region to its south. The population in the region is less dense than in surrounding areas to the north, east, and south, but more numerous and evenly distributed than in the sparsely peopled Central Sand Plain to the west beyond the limits of glaciation.

The Central Glaciated Sand Region, like the rest of southern Wisconsin, was utilized for wheat production during the early years of its occupance. Yankees from the East, Scotch, English, and Irish from the British Isles, and Germans and Norwegians were the settlers. Nearly all reached the area by way of overland highways from Milwaukee. That metropolis of Wisconsin, and leading port of the lake shore, was reached by sailing vessel from Buffalo, and became important during the ten to twenty years following completion of the Erie Canal in 1825. A "pinery road" from Milwaukee to Stevens Point, in the heart of the Wisconsin lumber district of the day, crossed the sand country. The Wisconsin River, the main north-south artery to and from the pineries, flowed just to its west. The first permanent white settler of Adams County, Walsworth, established a trading post and tavern on the pinery road in 1838. A cluster of farms grew around this post, and the settlement period began in earnest. Later roads from Milwaukee were pushed to the sand country across the lands of southeastern Wisconsin. Milwaukee, by way of these various highways, became the entrance point for the farmers who developed the region. Vermonters and New Yorkers were in the vanguard of the Yankees, but Yankee and foreigner alike arrived by way of the well established Erie Canal–Great Lakes–overland route.[6] The early settlers of the Glaciated Sand Region,

[5] Guy-Harold Smith, "The Populating of Wisconsin," *Geographical Review*, Vol. 18, 1928, pp. 402–421.

[6] John Muir, the famous naturalist, tells of the manner in which his Scotch father selected their Wisconsin homestead in the Sand Country in 1849. The family abandoned plans to settle in Upper Canada, and reached Buffalo instead. On "wavering" westward the Muirs were told by a Buffalo grain-dealer that most of the wheat he handled came by lake from Wisconsin. This information took the family to Milwaukee,

on the whole, do not seem to have been markedly affected by the fact that they were settling a sandy territory, nor by the fact that, in order to reach it from Milwaukee, they crossed fine silt loam lands—today the excellent farm country of southeastern Wisconsin and one of the leading agricultural districts of the United States. Wheat was in the air. Get to the land and seed the wheat crop. What matter if the land is sandy—it'll grow wheat. Land is cheap. We can move on. Get hold of the land that is closest; we must hurry with the wheat. When wheat production per acre began to decline, as it did on the glaciated sands before the decline began to take its toll on the heavier soils, the settlers abandoned the fields, cleared new land, again in the sand, or shifted the scene of their operations to a new site in the West.[7]

DECLINE OF PIONEER SOURCES OF INCOME

Gradually the "new" sandy lands likewise were depleted of much of their limited fertility. The sand country, like the rest of southern Wisconsin, was ready for a change, ready to listen to the state prophets and preachers of dairying, and ready to attempt the industry which was revolutionizing the agriculture of the southeastern part of the state. Ready, too, because a few of the settlers themselves had discovered the efficacy of dairying. These few had noted that English clover would grow on even the exhausted fields. When the clover was plowed under, and followed with corn or wheat, larger crops were raised. Cattle and swine were gradually added to the farm economy during the latter portion of the nineteenth century, and the clover-corn rotation helped to feed them. Wheat was giving way to the dairy cow.

The early situation of the Central Glaciated Sand Region with respect to markets in the lumber camps and towns of northern Wisconsin to its north was favorable. From 1840 until after 1880 the region was located about as close to the lumbering districts as were any of the agricultural

where they hired a farmer to take them to the edge of settlement—then Kingston at the margin of the Sand Country. At that village a land-agent gave them a note to a farmer living on the edge of the settled territory, who helped them locate a farm on the shore of one of the Sand Country lakes. This farm, according to John Muir, was soon so worked out that in 1857 the Muirs sold it and began the laborious process of clearing a new sand farm some twelve miles away from the original homestead. John Muir, *Story of My Boyhood and Youth,* Boston, Houghton-Mifflin Company, 1913.

[7] John Muir's father shifted the scene of his farming operations in eight years. In his book, John Muir notes that wheat, the principal crop, yielded twenty to twenty-five bushels an acre when the virgin sandy soil was first plowed, but only five to six bushels an acre, even in the better fields, after four or five years (pages 199–200). John Muir left home for college in 1861 with a few dollars that he had made by raising some grain on a *sandy abandoned patch of ground* (page 263).

sections of the southern portion of the state.[8] Furthermore, the Wisconsin River was the scene of great log drives. A result of the geographical situation was contact with the pineries. Lumber camps helped furnish a market for food and draft animals. Farm income could also be supplemented by a winter of working in the woods. Some camps hired the farmer's team as well. During the wheat stage and continuing awhile thereafter until logging declined in Wisconsin, the income of certain of the inhabitants of the Sand Region was thus gained from dependence upon two areas. The eventual demise of lumbering forced them to live from farming alone. The cessation of a steady income from lumbering corresponded in general period with the wheat difficulties—declining yields, insect pests, competition with the western prairies; consequently, due to a combination of a variety of circumstances, many farmers of the Central Glaciated Sand Country were willing to try the dairy style of agriculture, a farming type already developed in southeastern Wisconsin. (Table I. Milk cattle per square mile in the listed Southeastern Wisconsin Counties, 1870, 1880, 1890.)

TABLE I

MILK CATTLE PER SQUARE MILE, 1860–1940

	Area (sq. mi.)	Milk cattle per square mile								
		1860	1870	1880	1890	1900	1910	1920	1930	1940*
Southeastern Wisconsin counties										
Dodge	897	15.03	18.18	24.80	38.42	51.30	62.15	72.80	81.65	90.04
Fond du Lac	726	14.32	19.66	23.33	40.75	45.10	59.25	69.00	80.50	87.74
Jefferson	552	15.58	21.18	33.33	54.40	66.70	73.25	79.60	82.90	87.37
Manitowoc	602	1.99	15.53	24.10	42.80	41.80	59.35	65.20	76.20	81.87
Ozaukee	233	20.77	24.20	33.80	51.20	50.40	69.10	75.10	74.45	83.70
Sheboygan	521	14.47	20.12	36.70	60.55	59.30	75.80	76.70	81.75	84.43
Washington	431	17.12	19.63	24.74	37.40	44.16	56.25	65.95	75.45	81.40
Waukesha	549	16.92	19.13	24.85	35.19	41.90	58.20	71.10	76.20	85.92
Total	4,511									
Counties partly or wholly in Glaciated Sand Region										
Adams†	684	2.61	3.77	5.11	6.38	7.85	13.30	12.02	11.22	14.56
Columbia	778	10.77	12.42	17.26	21.70	24.80	32.60	36.40	44.85	49.59
Green Lake	360	12.50	12.08	15.86	20.23	29.57	40.50	41.90	47.85	54.17
Marquette	457	7.52	7.52	9.71	11.90	15.90	22.48	25.05	25.25	27.83
Portage	812	1.44	3.72	5.95	9.25	12.63	23.14	25.55	31.33	33.15
Waupaca	759	2.24	4.75	9.35	15.53	25.37	41.10	48.75	55.10	60.19
Waushara	646	4.03	4.85	9.92	15.73	19.36	27.08	26.85	29.26	32.00
Total	4,496									

* 1940 data from U. S. Department of Agriculture and Wisconsin Department of Agriculture Crop Reporting Service.

† Much of Adams County lies in the Sand Plain beyond the moraine.

[8] See the ten-year set of Wisconsin population maps in Smith, *op. cit.*

DAIRYING IN THE CENTRAL GLACIATED SAND REGION

The dairy industry is today the chief farming type of the Central Glaciated Sand Region, and the majority of farms of the region are classified either as dairy farms or as general farms. This section of the paper and the ensuing tables will present statistical evidence of the increasing intensity of the dairy industry in the Glaciated Sand, and will offer a comparison of the dairy industry of the region with that of an arbitrarily selected district of southeastern Wisconsin. The counties of the two areas to be compared cover essentially the same number of square miles. The various statistical compilations are presented in Tables I and II.

TABLE II

MILK CATTLE PER FARM, 1870–1940

	Number of milk cows per farm								Percent of farms reporting dairy cows, 1935
	1870	1880	1890	1900	1910	1920	1930	1940	
Southeastern Wisconsin counties									
Dodge	3.32	4.29	6.60	9.23	11.76	14.10	15.97	18.16	94.9
Fond du Lac	3.48	3.74	6.88	7.55	10.13	11.95	14.30	16.68	93.3
Jefferson	3.58	5.29	8.94	10.67	12.05	13.46	14.28	15.81	93.6
Manitowoc	2.43	3.33	6.32	6.18	9.14	10.05	12.17	13.88	94.9
Ozaukee	2.94	3.92	6.29	6.79	9.38	10.13	11.04	12.88	86.0
Sheboygan	2.86	5.12	9.01	8.66	10.83	10.91	12.14	13.51	93.2
Washington	2.86	3.47	5.66	6.62	8.68	10.15	11.93	13.68	93.3
Waukesha	3.29	4.24	5.84	6.48	9.10	11.45	13.22	15.71	84.2
Counties partly or wholly in Glaciated Sand Region									
Adams	2.54	2.75	3.06	2.92	5.42	5.28	6.19	7.82	90.6
Columbia	3.07	4.21	5.50	5.62	7.62	8.52	11.47	13.00	90.9
Green Lake	3.20	3.33	4.68	6.07	9.10	10.01	12.27	13.71	93.1
Marquette	2.89	3.36	3.62	4.77	6.97	8.00	8.85	10.10	92.0
Portage	2.33	2.39	2.86	3.24	5.82	6.24	8.43	9.61	89.7
Waupaca	2.23	2.54	3.55	5.26	8.21	9.81	11.97	13.49	90.3
Waushara	2.41	3.08	4.34	4.57	6.67	7.03	8.65	10.23	90.3

The striking features of dairying in the Central Glaciated Sand Region are (1) its moderate intensity of the present, and (2) its relative position behind the districts of southeastern Wisconsin. The relative picture has appeared in each recent Census. Today the density of cattle population in the Glaciated Sand is as great as the cattle density of southeastern Wisconsin thirty to forty years ago. Yet in 1900 and 1910 the Sand Region was likewise lagging behind the dairy development of the southeast. Each Census has brought out the relative picture; as one section has intensified, so has the other. The result is the Central Glaciated Sand, as compared in dairying to other developed portions of the state, is (1) less outstanding

relatively, and (2) less important absolutely. It has been overshadowed by most of its surrounding country, except on the west.

PRESENT DEVELOPMENT OF THE INDUSTRY

The farms of the Central Glaciated Sand Region support nearly 150,000 dairy cows. Approximately 40% of these cattle are of the Holstein breed; 30% are Guernseys, and 25% are of mixed grade stock. In addition there are occasional herds of Ayrshire, Jersey, and Brown Swiss cattle, and a few herds of dual purpose beef-and-dairy breeds. Some farmers maintain herds of beef cattle alone, but they form the exception, not the rule.

The farms upon which the dairy cattle are quartered average just under 200 acres in size for the region as a whole. Forty per cent of the farm area of the region is given over to crop land, used for the production of feed and forage crops for the cattle and for the "cash-crops" which are sold directly from the farm (Fig. 4). The crop land is devoted mainly to hay,

FIG. 4.—Rolling glacial terrain in the Glaciated Sand Region in southwestern Waupaca County. Dairy farm, rye-potato cash crops, wooded drumlins. (Wisconsin Geological Survey Photograph.)

corn, and oats—all of which are used upon the farms themselves, and which help furnish the winter food supply—and to the "cash crops" of winter rye, potatoes, cucumbers, and beans. The 60% of non-crop land is devoted to marsh hay and to pasture and woodland. Marsh hay is most important in many of the districts that contain great areas of ill-drained glacial terrain. In Marquette County, in 1940, the acreage of harvested "wild hay" actually exceeded the harvested acreage of all tame hays; in Green Lake County was 68% of the tame hay acreage; in Adams County 58%; and in Waushara

27%. (See Table III.) Pasture may be in rotation or may be permanent, principally the latter. Pasture grades into woodland so far as land use is

TABLE III

CERTAIN CROP ACREAGES, 1940

	Hay acreage, 1940		Cash crop acreage, 1940			Cows and heifers 2 years old and older kept for milk, 1940
	Clover, timothy, alfalfa, sweet clover, Sudan grass, millet for hay	Wild hay	Potatoes	Rye	Cucumbers	
	Southeastern Wisconsin counties					
Dodge	71,842	18,214	2,749	1,276	7	80,772
Fond du Lac	73,641	5,041	2,181	781	13	63,706
Jefferson	45,923	12,569	1,252	615	19	48,230
Manitowoc	81,751	820	1,729	1,041	30	49,290
Ozaukee	30,594	224	1,305	293	27	19,504
Sheboygan	61,224	155	1,651	608	36	43,990
Washington	45,679	1,201	3,153	1,100	20	35,086
Waukesha	59,684	7,683	2,637	1,383	77	47,170
	Counties partly or wholly in Glaciated Sand Region					
Adams	15,373	9,024	2,114	16,982	131	9,964
Columbia	48,102	11,765	2,954	8,405	113	38,584
Green Lake	24,338	16,781	1,251	5,552	97	19,504
Marquette	17,971	20,826	1,967	19,555	88	12,720
Portage	61,967	9,964	20,460	15,987	303	26,924
Waupaca	68,025	3,297	9,278	2,385	491	45,686
Waushara	39,868	10,937	7,434	17,892	442	20,670

concerned. Most woodlots, therefore, are pastured, but not all pastures are wooded. Within the region, the large proportion of the farms not in cropland thus functions in the dairy economy, and furnishes summer feed and some winter feed to the dairy herds.

The creamery is the chief manufactural unit for the milk produced on the farms of the Central Glaciated Sand Region. Thirty-eight creameries are located in the counties of the region; this is one of two sections of Wisconsin wherein butter is the major dairy product—the other being the Mississippi River side of the state. Twenty-two cheese factories within the area, and some just beyond its borders, compete with the creameries for a share of the raw mik (Fig. 5). Twenty-one receiving stations buy milk for outside creameries, cheese factories, or condenseries. Milk from part of the Sand Region, principally the northern, is trucked to neighboring condenseries, which are located in cities and villages beyond the borders of the region. No condensery or evaporating plant is located within the region proper.

The creamery is admirably suited to the conditions of the Central Gla-

ciated Sand Region. The region, while important in dairy production, is not an intensive dairy region. Milk production per unit of area or per farm is not so great as in the highly developed dairy lands of other portions of Wisconsin. Farms are large, and relatively distant from one another. A condensery or cheese factory requires absolutely fresh whole milk, delivered daily. Cream need be collected by the creamery, or hauled to it by the farmer, only two or three times a week. Butter is commonly manufactured from sour cream. Thus the farm's milk is separated upon the farm itself, the skim milk is used for feed at home, and the cream is delivered to the creamery.[9] In the Glaciated Sand Region as a whole 75 to 80% of the total milk production reaches creameries. Marquette County, in the center of the area, had 92% of the total number of its milk cows producing milk for creameries in 1935. Seven percent of the county cattle were producing milk for cheese factories, and 1% for city and village market milk in the same year. Only locally within the entire region do uses of milk other than for the manufacture of butter become prominent.[10]

FIG. 5.—Cheese factory built of glacial boulders, located in the sandy loam region near the common meeting point of Columbia, Marquette, and Green Lake counties.

[9] Delivery of cream to the creamery is made three or four times a week in the summer season, but only about twice a week in the winter. Ninety-six percent of the butter is made from sour cream, but a few creameries specialize in the manufacture of sweet cream butter. In such cases daily haulage is necessary during the summer season. "Creamery" is used in the Wisconsin and midwestern sense in this article—an establishment for the manufacture of butter.

[10] The average creamery, as may be deduced for the above figures of number and percentage, is larger than the average cheese factory. The creamery draws raw material from a wider area and from a greater number of cows.

Dairy barns, milk houses, silos, and similar visible accompaniments of the dairy industry are common landscape features of the Central Glaciated Sand Country (Fig. 6). The dairy barns are, however, not uniformly so

FIG. 6.—Farmstead of the very southern portion of the Sand Region.

large nor so well kept as in southeastern Wisconsin. They are usually in fair to good repair, are commonly painted red, and are prominent enough cultural features to impart an air of prosperity to the Wisconsin glaciated sand landscape that is often not found in sandy areas elsewhere that possess other farming types (Fig. 7). Silos are not so numerous as in the older

FIG. 7.—A better than average dairy farm in the sandy loam area of Columbia County.

dairy districts of southeastern Wisconsin, or the Driftless Area regions of the southwestern portion of the state. In 1937 Marquette County possessed 25 silos per 100 farms, Waushara 43 per 100, Portage 52, in contrast to numbers above 90 per 100 farms in southeastern Wisconsin, and 60 to 75 in the Driftless Area to the southwest.[11] The lower percentage of silos in the Glaciated Sand Region is due in part to the later start, in part to the less intensive past emphasis upon dairying, and in part to lower farm incomes. Silo building is continuing in the region as more farmers feel able to afford them, or increase their herds to such a size as to make the silo a necessity. The somewhat smaller herds of many farms are fed corn, grain, purchased concentrates, clover, alfalfa, timothy, and wild hay during the winter feeding season of six months or more. As either income or herd increases, the silo tends to appear. Whether the total number will ever reach the silo density of southeastern Wisconsin is a question that time alone can answer.[12]

The tables present figures of average number of milk cows per square mile and per farm (Tables I and II). Differences between the selected counties of southeastern Wisconsin and the Glaciated Sand Counties are less on a per farm basis than on a total area basis (a reflection of the much larger average size farm of the Sand Region). For example, in 1940 the intensive dairy counties of Dodge, Fond du Lac, Jefferson, and Waukesha possessed 90, 87, 87, and 85 milk cows per square mile of area, and 18, 16, 16, and 15 milk cows per farm. In the same year Marquette, Portage, Waupaca, and Waushara counties had 28, 33, 60, and 32 milk cows, respectively, per square mile, and 10, 10, 13, and 10 milk cows per farm. It will be noted that the four above-mentioned southeastern Wisconsin counties had about the same milk cattle density per square mile in the 1880–1890–1900 period as the Central Glaciated Sand Country possesses today; and in 1910 they had 12, 10, 12, and 9 milk cows per farm—essentially similar per farms figures with the Sand Country at present.

Advent and intensification of the dairy industry in the Central Glaciated Sand Region has been accompanied throughout the years by an increasing size of landholding, while in southeastern Wisconsin the average size of farm has remained practically stationary for fifty years, and in one or two areas the average has actually declined somewhat. In Marquette and Wau-

[11] Two southeastern Wisconsin counties had more than 100 silos per 100 farms in 1937—Dodge 109, Washington 102. Others were just below 100, as Sheboygan 99, Jefferson 98, Waukesha 97.

[12] The Wisconsin Agricultural Experiment Station has now developed methods of storing silage in pits under the ground. The earth covering is removed as the succulent feed is needed.

shara counties the average increased from 155 and 125 acres respectively in 1880 to 193 and 154 acres in 1930 (188 and 147 in 1935). This increasing average was accompanied by a decrease in the total number of farms. Marquette County reached its maximum number of 1523 in 1900, and declined to 1302 in 1930, 1259 in 1940; Waushara County possessed 2739 farms in 1900, but 2186 in 1930, and 2019 in 1940.[13]

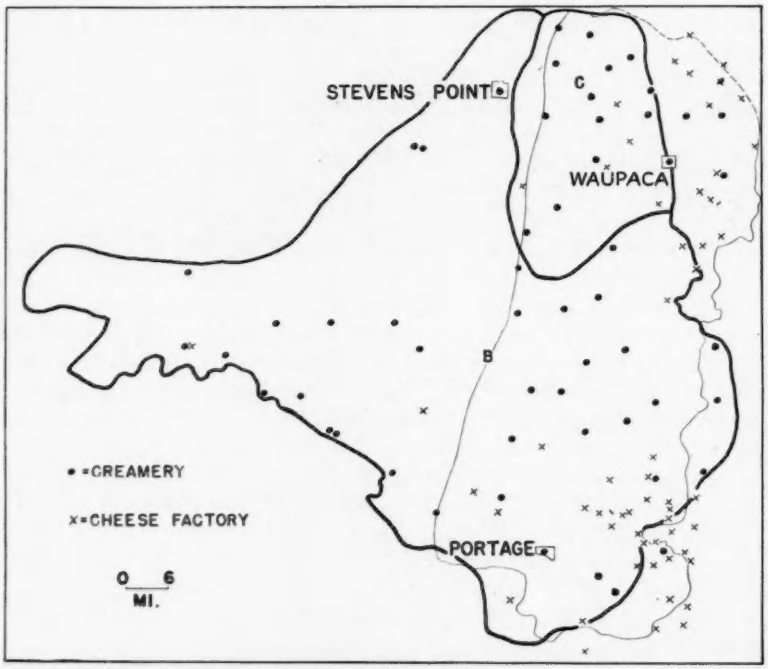

FIG. 8.—Creameries, cheese factories, and the United States Department of Agriculture's Farming Types Regions of the sandy lands of Central Wisconsin. The Central Glaciated Area is outlined by the fine line. Note the large number of dairy manufacturing plants in the region. **B** on the map is region 266B of the Farming Types Map: "Wisconsin Central Sand Plains—Dairy, Livestock, Potatoes, Field Peas, General." **C** is region 266C: "Dairy, Potatoes." Region **B** was classified in 1930 as "General Farming": region **C** as "Dairy Combination."

[13] A slight increase from 1930 to 1935 probably reflected chiefly the "depression-return" to the land from the Lake Michigan shore cities, and particularly the re-occupation of many abandoned sets of buildings in the Sand Area—buildings that fell into disuse during the period of farm enlargement. In 1940 the downward trend in numbers, and increased average size, was again evident.

The increasing size of farm in the Central Glaciated Sand Country has accompanied development of dairying, and has permitted many of the farmers to increase the size of their herds. It has given the individual farm a greater acreage of both crop and pasture land. Yet the primary reasons for the increase in size have been the poor soil, marginal and submarginal sandy lands in many sections, attractions of the city, and similar economic factors—reasons associated with matters other than dairying. The result has not so much been "farm abandonment" as it has been "farm absorption" with consequent increase of average acreage.[14]

FARMING PRACTICES ASSOCIATED WITH DAIRYING

The dairy farms of the Central Glaciated Sand Region devote part of their acreage to the production of "cash crops"[15] (Fig. 8). These crops are sold directly from the farms, and supply the percentage of income that is derived from the sale of crops (Table III).

Potatoes are the leading cash crop of the northern portion of the Central Glaciated Sand Country—the area in Waupaca, Portage, and parts of Waushara counties. Rye is the leading crop for direct sale in Marquette and Adams counties, as well as in many towns[16] of Waushara County. The presence of these two crops reflects the sandy and sandy loam soils (Fig. 9). Other cash crops, likewise, are those which yield best under somewhat adverse soil conditions, or else are admirably suited to the soil types. Buckwheat, beans, cucumbers, and melons are examples of these. Locally within the region the presence of a particular cash crop may have a pronounced effect on the landscape. "Pickle stations" are located in the cucumber sections. Potato warehouses, "potato sidings" leading from main railroad lines to producing areas, and even the "potato vacation" of the schools (wherein October, potato-digging time, is a vacation month, so that rural schools open in August) are all regional characteristics of parts of the area. The sandy central portion of Wisconsin obtains a greater percentage of its farm income from the direct sale of crops than do other agricultural sections of the state, hence is partly listed as general farming or as dairy combination on the Farming Types map (Fig. 8). In 1933, for example, sale of

[14] A tendency to increase farm acreage further is now showing itself (1941). This is due to increased use of tractors, and the getting of other farm machinery "on rubber tires." Outlying fields may be rented, and a large enough farm acreage, even of relatively poor sand, may be brought under the management of a single operator to support him.

[15] Fifteenth Census of the United States. Census of Agriculture, *Types of Farming in the United States, 1930.* U. S. Department of Commerce, Bureau of the Census, Washington, 1933.

[16] In Wisconsin, as in New England and New York, the *town* is the rural unit (the township of other parts of the northern United States).

FIG. 9.—Rye field, oak woodland, brushy pasture—a common landscape of the Glaciated Sand Region. (Wisconsin Geological Survey Photograph.)

crops accounted for 37% of the gross income in Portage County, 23% in Marquette, 24% in Waupaca, and 28% in Waushara County.[17] In that year 19.2% of Wisconsin's farm income was from the sale of crops, contrasting with the 1927–1936 decade average of 16.3%. In 1936 the proportions of gross income from crops in the four above mentioned counties was, respectively, 44%, 26%, 26%, and 31%, while the 1936 state-wide crop average was 16.1%.[18] Of the 1936 totals, Portage County farmers received 31% of their gross income from sale of potatoes, Waupaca 15%, Marquette 5%, and Waushara 14%. Grains, chiefly the rye, accounted for from 2 to 4% of the gross income.[19]

The last several years, the late 1930s and 1940, have witnessed serious crop difficulties to certain of the cash crops, particularly potatoes, within the Glaciated Sand Region. Individual farmers, deprived of a portion of their income, have turned increasingly to the dairy cow. Alfalfa can be started on the sandy and sandy loam soils, and yields a good hay crop after the "catch" has been established. Collectively in recent years the percentage of farm income from crops has declined slightly, and may decline further, though the oscillations of individual years may not constitute a trend. Collectively the income from cattle and associated products has tended to rise. Increasingly the local talk has been of the dairy cow.

[17] Wisconsin Crop and Livestock Reporting Service, *Wisconsin Agriculture, Bulletin 150, 1934*, p. 15.

[18] Wisconsin Crop and Livestock Reporting Service, *Wisconsin Agriculture, Bulletin 188, 1938*, p. 19.

[19] In the intensive dairy regions of southeastern Wisconsin, direct sale of farm crops accounted for but 10% to 14% of the total gross income in 1933 and 4% to 13% in 1936.

Income from the sale of dairy products in Wisconsin did not suffer a complete collapse during the depression years of the 1930s. While milk prices declined, they held relative to other products. An economic factor of this sort helped dairying in the Sand Country as well as in other portions of Wisconsin. The depression years witnessed increasing attention to milk production, and increasing numbers of milk cattle in the state. Each recent year has practically outdistanced the preceding year in an all-time high of dairy production. On February 1, 1941, milk production in Wisconsin was 9% greater than on February 1, 1940.[20] Better prices enjoyed by dairy farmers have undoubtedly helped increase interest in the industry in the Sand Region, as well as in other portions of Wisconsin. In the past, crop difficulties with wheat and competition with new wheat areas helped focus attention upon dairying. At present, crop difficulties with potatoes and competition with new potato areas is helping intensification of the dairy industry. Further development may be expected, but in no case can the area, with its sandy soils environment, hope to attain the maximum importance and concentration of dairying that may be attained in southeastern Wisconsin.

The introduction of cultural elements associated with intensive dairying has tended to improve the appearance of the average farmstead within the Glaciated Sand Region. Larger barns than the region formerly possessed have become almost a necessity. Addition of larger barns to the area has, perhaps more than anything else, brought it a certain degree of similarity to the cultural landscape of other parts of the state, and has helped to make the Wisconsin Glaciated Sand Region different in appearance from sandy regions in portions of adjacent states or regions. Addition of these cultural elements, as well as of milk houses, silos, and other features of dairying, has not been accomplished 100%, however. The occasional dilapidated sand farm remains—not typical now in the Glaciated Sand, but more typical of the barren, almost non-agricultural Sand Plain to its west, beyond the moraine. However, there are spots of several square miles in extent which are sub-marginal in character, or below average in use, and appear as locally poor sections, so that cultural variety is imparted to the region. The variety of the landscape is lost in statistical averages; the region, when seen in the field, does not possess the essential uniformity of farm lands so characteristic of the dairy lands of southeastern Wisconsin. Yet the sandy and sandy loam soil is an element around which the regional character has been built, and an element dominant in the regional character.

CONCLUSION

The Central Glaciated Sand Region of Wisconsin is a dairy-cash crop

[20] *Wisconsin Crop and Livestock Reporter*, Vol. XX, No. 2, February 1941.

farming area. Dairying has increased manyfold in the region since the early dependence on wheat. Hay, corn, oats, rye, and potatoes have almost completely eliminated wheat from the landscape. The dairy industry advanced into the Glaciated Sand Region from other parts of Wisconsin. Adjacency to developing and developed dairy areas was a factor in the advent of the industry to this region of none too propitious soils environment. As the dairy industry "crept" into the Glaciated Sand it intensified in southeastern Wisconsin. Intensification and enlargement of the dairy enterprise in the Sand Country during the last fifty years has been overshadowed by extreme intensification in the southeast, bringing that part of the state to its present national position. The conclusion seems inescapable that dairying has crept inward upon the Sand Area from the surrounding silty loam lands, where it started in response to changing economic factors, to preaching by Governor Hoard and faculty members of the College of Agriculture, and to the decline of wheat-growing. It has increased in both relative and absolute importance in the Central Glaciated Sand Region despite the presence of the sandy soils with their relatively poor hay and pasture possibilities. The large size farms in the sand have permitted extensive grazing practices on the landholdings. Each farm, therefore, may have a herd per farm not far different in size from the herd per farm in the

TABLE IV

NUMBERS OF WISCONSIN CATTLE

Wisconsin cattle numbers on January 1*

Class of livestock	1941 (preliminary)	1940	1939	1938	1937
Cows and heifers 2 years old and older kept for milk	2,289,000	2,244,000	2,179,000	2,157,000	2,136,000
Heifers 1 to 2 years old kept for milk cows	464,000	448,000	424,000	410,000	402,000
Heifer calves being saved for milk cows	488,000	470,000	466,000	439,000	442,000
All other calves	88,000	75,000	75,000	70,000	78,000
Cows and heifers 2 years old and older not kept for milk	18,000	18,000	16,000	17,000	19,000
Heifers 1 to 2 years old not for milk	19,000	19,000	17,000	19,000	18,000
Steers 1 year old and older	72,000	63,000	61,000	61,000	48,000
Bulls 1 year old and older	104,000	102,000	101,000	101,000	99,000
All cattle	3,542,000	3,439,000	3,339,000	3,274,000	3,242,000

* Table from *Wisconsin Crop and Livestock Reporter*, Vol. XX, No. 2, February 1941. Issued jointly by the United States Department of Agriculture, Agricultural Marketing Service and the Wisconsin Department of Agriculture, Division of Agricultural Statistics.

better areas of Wisconsin; but the total cattle density in the region is less per unit area, and the carrying capacity per acre or per square mile is much less than on the excellent soils of southeastern Wisconsin.

What might this region have been in another setting? Speculation is futile. A geographical situation on the frontier west of the Great Lakes first brought it a wheat period. Geographical situation in a state that has turned wholeheartedly to the dairy industry for its rural utilization, and that possesses more cattle than total inhabitants (Table IV), has brought the dairy cow to the region. It now possesses a definite regional character —perhaps partly or totally unlike any other region on the face of the earth. It is the Central Glaciated Sand Region of Wisconsin.

University of Wisconsin.
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